Concrete Property Test

Workability 1-1: Combined Grading

National Concrete Pavement Technology Center

www.cptechcenter.org

Purpose – Why Do This Test?

Aggregate grading may influence the water requirement, workability, and paste content of a mixture. These in turn may impact the risk of segregation, bleeding, and increased shrinkage of concrete paving mixtures.

It is desirable to cost-effectively blend different aggregate sizes to obtain a smooth grading curve for the combined aggregates system.

Principle – What is the Theory?

The sieve analysis (amount of material retained or passing a series of sieves with different-sized openings) is compared to optimized systems using a number of numerical and graphical models. The closer the batch grading is to the optimum, the lower the risk of grading-related problems in the mixture.

Test Procedure – How is the Test Run?

Sieve analyses are conducted in accordance with ASTM C 136 for the coarse and fine fractions, and the data are applied to the following models.

The coarseness/workability chart plots a single point on a graph, with the coarseness factor on the horizontal axis and the workability factor on the vertical axis, where

Coarseness factor = ([percent retained on $^{3}/_{8}$-in. sieve] / [percent retained on #8 sieve]) • 100

Workability factor = percent passing #8 sieve • 100

The 0.45 power chart plots the combined grading on a chart with sieve size on the horizontal axis (scale = sieve size [µm] $^{0.45}$) and percent passing on the vertical axis.

The combined percent retained chart plots the material retained on each sieve with sieve size on the horizontal axis and percent passing on the vertical axis.

Test Apparatus (figure 1)

- Scale.
- Sieves.
- Oven.
- Mechanical sieve shaker (optional).

Test Method – Refer to ASTM C 136 for Comprehensive Guidance

1. Obtain a representative sample of the aggregates.
2. Dry the sample to a constant mass.
3. Sieve the sample.
4. Determine the mass of material retained on each individual sieve and calculate the percentage retained.

Output – How Do I Interpret the Results?

Points on the coarseness/workability chart (figure 2) represent the coarseness factor and the workability factor for a mixture based on the grading test results of each individual aggregate. For an optimized grading mixture, the points should plot above the control line (28<workability factor<44) and inside the zone labeled well graded (45<coarseness factor<75).

continued on next page

Figure 1. Sieve analysis test equipment

FOR MORE INFORMATION

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When the sample combined grading plot on the 0.45 power chart (Figure 3) crosses back and forth across the maximum density line, it indicates gap grading.

A general rule of thumb for optimized grading is to have between 8 and 18 percent retained on each individual sieve on the combined percent retained chart (Figure 4). Note that the combined gradation shown in Figure 4 has two sieves that fall outside the "8–18" band, but this does not necessarily indicate that the mixture is unacceptable. All three charts should be used in conjunction before determining that a mixture's combined gradation is unacceptable. Two or more points in a valley on the combined percent retained chart indicates a more severe gap grading condition that should be addressed.

Each of the charts (figures 2 through 4) provides a different perspective of gradation. When used together, the information in these three charts can provide the contractor and the agency with a basis for evaluating the combined grading of a concrete mixture.

Construction Issues – What Should I Look For?

Modest variations in grading are to be expected from batch to batch and generally do not have a significant impact on performance. Extreme variations in grading and workability should be addressed as they occur.

Workability concerns attributable to aggregate grading can be identified by observing the following conditions:

- Stockpile segregation and/or inconsistent stockpiling methods.
- Inconsistent slump (mixture water is static while grading changes).
- Excessive bleeding.
- Variation in vibrator frequencies.
- Edge slump.
- Poor consolidation observed in cores.
- Segregation observed in cores.

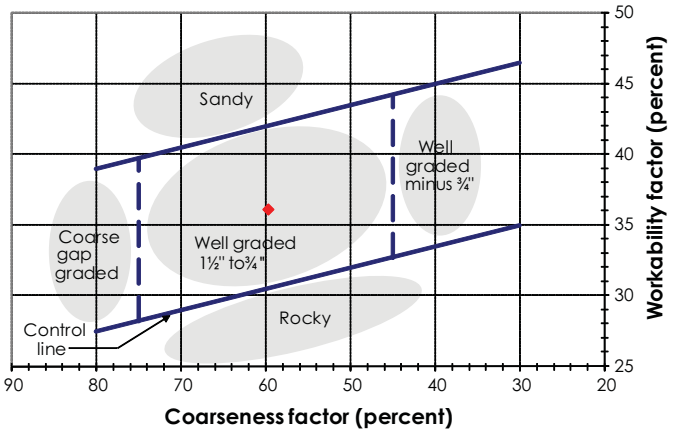

Figure 2. Coarseness factor chart

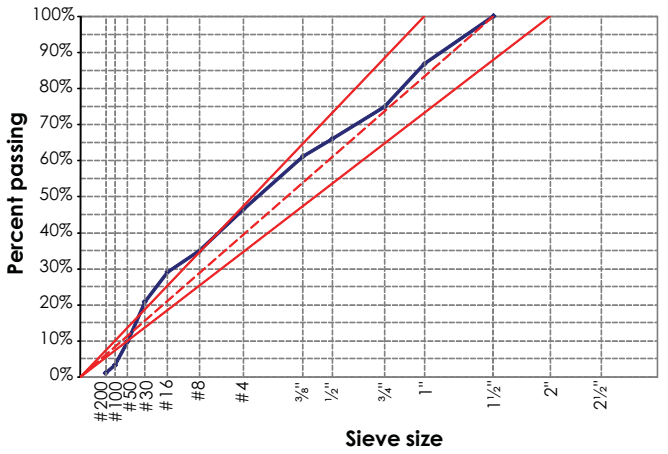

Figure 3. 0.45 Power curve

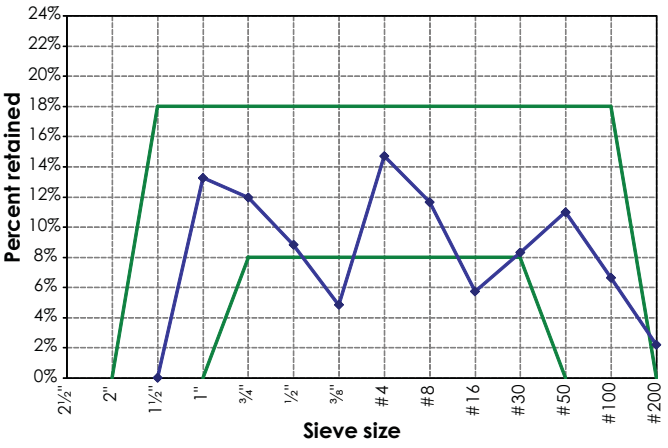

Figure 4. Combined percent retained chart with "8–18" limits

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