IN-LB	Inch-Pound Units
SI	International System of Units

Assessing Combined Aggregate Gradings—Guide

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This guide provides background and examples on the use of practical aggregate grading tools to improve aggregate performance in concrete and allow the paste content of a concrete mixture to be reduced while achieving satisfactory workability and physical properties. The aggregate grading of a concrete mixture impacts the workability, durability, strength, and sustainability of concrete. These grading tools can also be used to proportion concrete mixtures as well as troubleshoot issues associated with mixtures from high to low workability. This guide does not make recommendations, but it does describe and give examples of how to use these tools.

Keywords: aggregate; aggregate grading; coarseness factor chart; gap graded; individual percent retained (IPR) chart; particle shape; Power 45 curve; proportioning aggregate; tarantula curve; well-graded aggregate.

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CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

Aggregates make up approximately 75% of the volume of a concrete mixture and, therefore, aggregate can affect the strength, workability, pumpability, finishability, shrinkage, and durability of concrete (Cook 2015; Richard 2005; National Stone, Sand, and Gravel Association 2013; Kosmatka and Wilson 2016; Taylor et al. 2007). Many different mixture design methods exist for concrete, and they have different methods to address aggregate (Cook 2015; Richard 2005; National Stone, Sand, and Gravel Association 2013; Kosmatka and Wilson 2016; Taylor et al. 2007; Abrams 1918; Powers 1968; Goldbeck and Gray 1968; Shilstone 1990). All of these design methods identify the importance of the size distribution or grading of the aggregates to proportion coarse and fine aggregates. The methods in this document use a combined aggregate grading to improve packing and minimize paste content. It should be noted that even if an aggregate grading meets the suggested combined grading limits, this is not a guarantee that the mixture will produce a satisfactory concrete mixture and, therefore, adjustments to mixture proportions may be needed with trial batches. Practitioners have found mixtures with combined aggregate grading techniques to be more consistent, show increases in strength and a reduction in water demand, and allow a lower paste content when combined grading techniques are used (Cook 2015; Powers 1968; Goldbeck and Gray 1968; Shilstone 1990; Shilstone and Shilstone 1989).

1.2—Scope

This document provides some background literature and examples to help develop a combined aggregate grading for concrete mixtures from high to low workability using different aggregate grading techniques.

CHAPTER 2—NOTATION AND DEFINITIONS

2.1—Notation

C = cementitious material content, lb/yd^3 (kg/m^3)
D = maximum coarse aggregate size
d = current sieve size
P = value on x-axis for a given sieve size
Q = cumulative % retained on the 3/8 in. (9.5 mm) sieve
R = cumulative % retained on the No. 8 (2.36 mm) sieve
W = cumulative % passing the No. 8 (2.36 mm) sieve size

2.2—Definitions

Please refer to the latest version of ACI Concrete Terminology for a comprehensive list of definitions. Definitions provided herein complement that resource.

coarse sand—summation of the material retained on the No. 8, No. 16, and No. 30 (2.36 mm, 1.18 mm, and 600 µm) sieve size of the tarantula curve.

coarseness factor chart—graphical aggregate grading technique that uses the coarseness factor and workability factor to examine the aggregate grading.

fine sand—summation of the material retained on the No. 30, No. 50, No. 100, and No. 200 (600 µm, 300 µm, 150 µm, and 75 µm) sieve size of the tarantula curve.

individual percent retained chart—graphical aggregate grading technique that plots the percent mass retained on each sieve and compares this to an established limit.

Power 45 chart—graphical aggregate grading technique that compares the cumulative mass passing for each sieve raised to the 0.45 power.

tarantula curve—graphical aggregate grading technique that plots the percent mass retained on each sieve and compares this to an established limit with the shape of a tarantula. Additionally, two fine aggregate equations are used to calculate the fine sand and coarse sand and compare them to established limits.

CHAPTER 3—THEORY OF GRADING TECHNIQUES

3.1—Introduction

Aggregate grading techniques aim to increase the volume of aggregates through improved packing while decreasing the volume of paste to enhance the workability and other properties of the concrete. While no single aggregate grading procedure considers all mixture requirements, such as the aggregate size distribution, cementitious materials, admixture combinations, maximum aggregate size, passing ability, segregation resistance, or pumpability, practitioners continue to use aggregate grading techniques because of observed improvements in performance (Obla and Kim 2008; McCall et al. 2005; Varner 2010).