Impact of Equipment Type on Particle Size Measurement of Civil Engineering Materials

Tanner Turben
Advisor: Andrew Braham, PhD., P.E.
University of Arkansas College of Engineering, Fayetteville, AR

Introduction

- Particle size refers to the dimensional size of individual particles of a material.
- Two common measurement methods are the electrical sensing zone method (**Coulter Method**) and **Laser Diffraction**.
- The **Coulter Method** utilizes changes in electrical resistance to measure particle size.
  - Particles are suspended in an electrolyte solution which flows though and aperture tube.
  - An electrode is positioned within the aperture tube and a second electrode outside the aperture tube.
  - Observed change in electrical resistance is used to determine the volume of the particle.
  - Volume can then be converted to an equivalent spherical diameter.
- The **Laser Diffraction** method utilizes the light scattering behavior of small particles to determine their size.
  - Particles are suspended in a dispersion medium and pass into the line-of-sight of a laser beam.
  - The laser beam is scattered by the particle and received by an array of photo detectors.
  - The input pattern received by the photo detectors is then used to calculate a particle size distribution.
- Both methods can be used to measure large numbers of particles and produce a **particle size distribution**.
  - Typically represented as the volume or count of sample particles to particle diameter on a semi-log plot as shown in **Figure 1**.
  - Common properties of the distribution include mean, median, and mode.

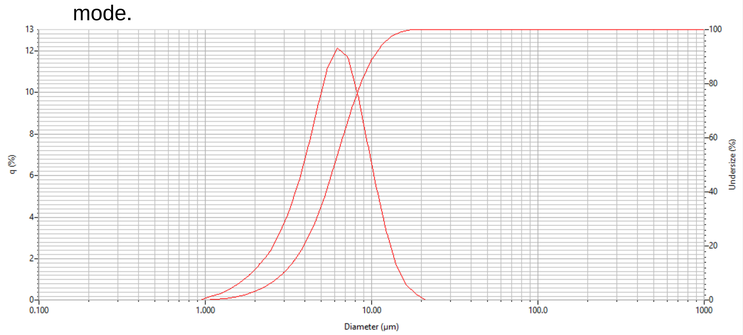

Figure 1. Example of an asphalt emulsion particle size distribution curve.

Objectives

The objectives of this study are as follows.

- Recognize and mitigate any differences in reported particle size between measurement methods
- Identify shortcomings of the measurement methods present for any material
- Relate results obtained using one measurement method to another measurement method
- Provide better understanding of particle size analysis procedures for future specifications

Existing Research

- The method of particle size measurement has previously been identified to influence reported results in the past.
  - Laser diffraction reported larger particle sizes among clay particles compared to sieve-pipette (Ramaswamy and Rao, 2006).
  - Laser diffraction reported larger particle sizes compared to dry sieving (Blott and Pye, 2006).
- Little research exists on comparing different particle size analyzing equipment.
- The particle size of materials affects important characteristics of those materials and their applications or use.
  - For asphalt emulsion, the droplet size affects storage stability and viscosity (Querol et al., 2017).
  - Storage stability is resistance to binder dropping out of suspension.
  - Viscosity is pertinent to pumping asphalt emulsion for many applications
- Many factors including emulsifier dosage, soap temperature, pH, shear time, and asphalt temperature can all be adjusted to control particle size during emulsion production (Chen et al., 2022).
  - Understanding particle size measurement techniques will benefit future application of standards pertaining to producing and validating emulsions.

Research Plan

This study will use the Coulter method and Laser Diffraction method to analyze particle size using two pieces of equipment.

Horiba Partica Mini LA-350 Laser Scattering Analyzer

beckman.com

Beckman Coulter Multisizer 4 Particle Analyzer

The following materials will be tested.

Category	Material 1	Material 2	Material 3
Standard	Duke Standards	-	-
Bacteria	Cyano	Bacillus	-
Cementitious	Portland Cement	Fly Ash	Silica Fume
Emulsion	CSS	CMS	-
Sand	Manufactured Sand	Natural Sand	-
Clay	Kaowhite	Bentonite	-

Finally, the plots of volume vs log particle diameter, plots of number vs log particle diameter, D_{10}, D_{50}, D_{90}, mean, span, and chi squared will be obtained using both machines for all materials and compared to satisfy the research objectives.

Anticipated Results

- It is anticipated the reported particle size for highly spherical materials will be similar between measurement methods.
  - Asphalt emulsion expected to be be nearly identical
  - Both the coulter method and laser diffraction software assume a spherical shape to report particle diameter, their readings are expected to be similar for materials with spherical particles.
  - Distinction between the Coulter method and laser diffraction method may not be pertinent for developing an asphalt emulsion particle size specification.
- It is anticipated that the particle size distribution obtained will differ most greatly for non-spherical materials.
  - Rod-shaped materials (12×1.7×1µm) were reported as 1-12µm in diameter with laser diffraction as shown in **Figure 2** (Kelly and Kazanjian, 2006).
  - Laser diffraction does not characterize particle shape.
  - Coulter method does not characterize particle shape, but may report lower span (less variability) due to its volume-based measurement principle.
  - Results obtained by Coulter counter and laser diffraction analyzer are expected to differ for materials like Portland cement

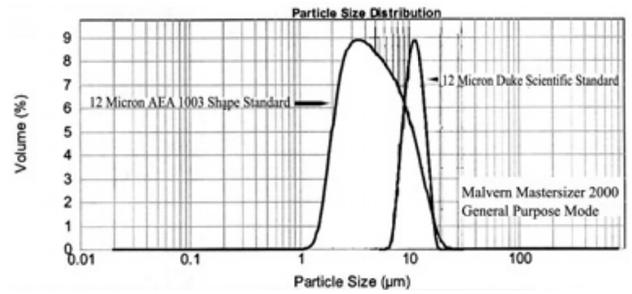

Figure 2. AEA 1003 volume distribution results using Malvern Mastersizer 2000 (Kelly and Kazanjian, 2006)

Acknowledgements

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