The Ohio Department of Transportation
Office of Innovation, Partnerships & Energy
Innovation, Research &Implementation Section
1980 West Broad Street
Columbus, OH 43207
614-644-8135
Research@dot.state.oh.us
www.dot.state.oh.us/Research

Executive Summary Report

A COMPARISON OF OPTICAL GRADATION ANALYSIS DEVICES TO CURRENT TEST METHODS

FHWA Report Number:	FHWA/OH-2012/5
Report Publication Date:	April 2012
ODOT State Job Number:	134330
Project Duration:	36 months
Start Date:	January 2007
Completion Date:	December 2010
Total Project Funding:	$114,120
Research Agency:	INFRASTRUCTURE MANAGEMENT & ENGINEERING
Researchers:	Dr. ARUDI RAJAGOPAL
ODOT Project Manager:	
ODOT Subject Matter Experts:	Jeff Wigdahl

For copies of this final report go to http://www.dot.state.oh.us/research.

Project Background

Sieve analysis, also known as *gradation analysis*, is a process of determining the particle size distribution of a granular material. The results of sieve analysis provide the basic data needed for the design and analysis of cement concrete and asphalt concrete mixes. Traditionally, gradation analysis is conducted by sieving a sample of granular material through a set of sieves. The percentage material retained on each sieve is obtained by measuring the amount of material retained on each. The results are generally presented in the form of a graph of cumulative percentage of material passing through each sieve size. It is generally felt that sieve analysis test is time consuming.

In the recent times, new methods are being devised to expedite and rationalize the aggregate test results. Most notable among the new technologies are optical test methods that use computer controlled video enhancement pictures. The primary intent of using such devices is to obtain faster results with, less labor, less consistency error, and greater reliability.

In its continuing efforts to improve its material testing practices in Ohio, the Ohio department of Transportation's Office of Material Management initiated a study to conduct a critical review of the available optical devices, and provide basic data to determine when and where such devices are appropriate from the standpoint of both economies and performance. The basic focus of this study was on two issues:

- What types of optical devices are in use or under investigation by other agencies?
- Do these new devices have potential applicability to Ohio's conditions?

Study Objectives

1. Conduct a review of available optical *gradation analysis* devices that are in use and/or being investigated by other agencies,
2. Select optical device(s) for evaluation,
3. Prepare physical samples and conduct *gradation* tests on a range of materials using current ASTM/AASHTO procedures,
4. Repeat tests on physical samples using selected optical device(s),

5. Investigate the applicability of the device(s) to determine *Flakiness and Elongation Index* (*F/E*) and *angularity*,
6. Analyze the data and make recommendation about the capability, precision, durability, reliability and repeatability of the device(s).

Description of Work

The present study was taken up in two phases. Phase-1 focused on a review of devices pertaining to *gradation* (ASTM C136) tests. The study identified six optical devices. One of them, Computerize Particle Analyzer (CPA) developed by Haver and Boecker became available for investigation. CPA is a photo-optical device which uses 2-dimensional images for measuring the particle size distribution and shape of all dry bulk materials between 40microns and 36mm. 46 aggregate samples (sand sized to 25mm) comprising of limestone, gravel and slag were collected from various sources in Ohio. The *gradation* of each aggregate sample was determined using the traditional sieve analysis procedure. The same aggregate samples were tested using the CPA device. The goal of the study was to ensure good comparison between the results generated from the two test procedures. The early results showed considerable variation. Discussion with the device developers led to a procedure for calibration of the device prior to making runs. Ten representative aggregate samples were used to develop calibration constants. The results obtained after calibration of the system showed significant improvement between the two test procedures. The maximum difference between test results was less than 1%. Additional samples were brought in from different aggregate sources in Ohio. All the test results showed excellent comparison between the CPA and sieve analysis results. Following this, the study was extended into Phase-2 to further research the applicability of the devices for *Flakiness and Elongation Index* (ASTM D4791), and *Angularity* (ASTM D5821) tests. These parameters require mapping 3-dimensional view of individual particles and as such highlighted the limitation of the CPA device. The device manufacturers are pursuing modifications and redesign of the system in order to derive the additional parameters.

Research Findings &Conclusions

1. CPA device is capable of producing *gradation* results with great repeatability, reproducibility, reliability, and precision,
2. The results obtained in this study clearly demonstrate the capability of CPA in matching traditional sieve analysis results,
3. The device is rugged, durable, and user friendly,
4. A primary advantage of CPA is its capability to be installed as in-line systems for continuous monitoring at the crusher and/or asphalt plant. With such systems, the results are continuously transferred to the control plant for making necessary adjustments,
5. In its current format, the CPA is not capable of determining shape characteristics such as *angularity* and *F/E index*.

Implementation Recommendations

1. It is recommended that ODOT include the CPA device in the specification for gradation analysis.
2. It is recommended that ODOT will use the CPA device for the determination of %FF provided appropriate modifications are made to improve its capability to produce %FF with greater confidence.
3. In its current design, the CPA device is not recommended for the determination of F/E ratio.