Laser-based Aggregate Scanning System (LASS)

Studies have shown that the shape-related properties of stone aggregates, such as size, form, angularity, and texture, significantly influence the quality of hot mix asphalt and Portland cement concrete. For example, particle size distribution (gradation) affects a range of material properties, including durability, strength, and workability. It is also generally recognized that aggregates with angular shapes and rough surfaces tend to develop better particle interlocking and, consequently, improve the strength of the final material. While engineers have long recognized that particle shape plays a major role in determining the performance of a given construction material, it has not yet been possible to quantify this effect because it is difficult to accurately measure the shape properties of a large number of stone particles.

An automated system, called the "Laser-based Aggregate Scanning System" (LASS), was developed to scan and characterize construction aggregates in a fast, accurate, and reliable manner. Automatic measurement of particle properties is of great interest because it has the potential to solve such problems in manual measurements as subjectivity, labor intensity, and slow speed. One of the main innovations of the system is that, through the use of laser sensing techniques, the system acquires and analyzes true three-dimensional (3D) data from a large number of aggregate particles. This enables quick and accurate characterization of various shape properties such as gradation, elongation ratio, flatness ratio, angularity, and texture. In other words, multiple testing methods that are currently being used for aggregates can be replaced by this one innovative system with better accuracy and shorter testing time.

In its present state of development, the system is an excellent research laboratory device for characterizing irregularly shaped stone particles; the 3D data acquisition capability, along with the efficient analysis algorithms, provides accurate and fast characterization of aggregate particles. In addition, it is also suitable for filed applications such as aggregate production plants. When implemented, the ability to automatically analyze multiple characteristics of an aggregate sample is expected to provide the information necessary to optimize quality control during aggregate production.

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The Laser-based Aggregate Scanning System (LASS) consists of a laser scanner, a linear motion slide, and a personal computer (Figure 1). The laser scanner, which is mounted on the linear motion slide, passes over an aggregate sample, scanning it with a vertical laser plane. The laser scanner can move approximately 1.5 m along the Y axis with a scan width of 120 mm and a scan height (Z axis) of 220 mm. Thus, anything that lies within the range defined by the scanner travel distance, scan width, and scan height, can be scanned. By combining the individual accuracies of the linear motion slide and the laser scanner, the LASS can have resolutions of 0.3 mm, 0.1 mm, and 0.5 mm in X, Y, Z axes, respectively.

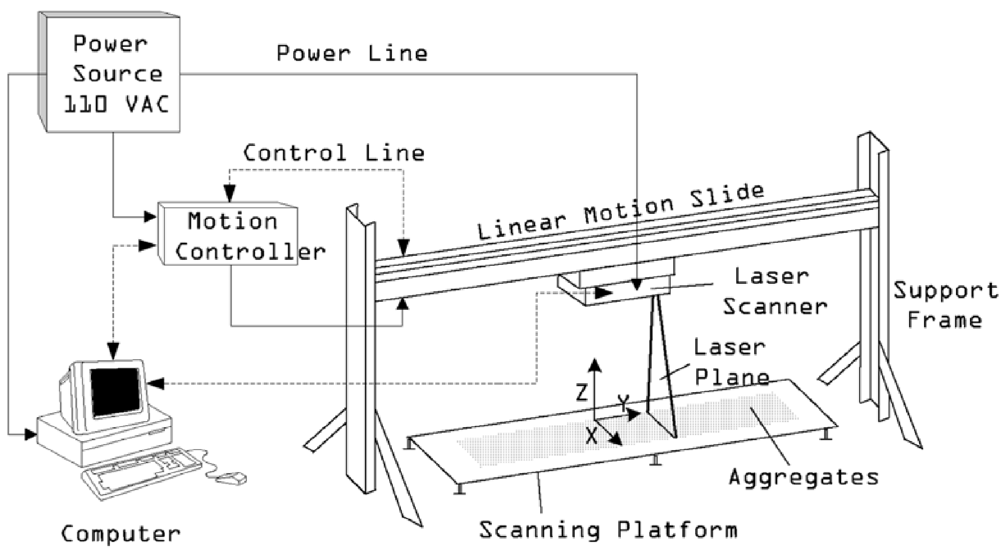

Figure 1: The LASS hardware architecture.

The LASS operates in the order of three-dimensional (3D) laser profiling, particle segmentation, and particle measurement. First, true 3D data for aggregate particles obtained by laser profiling are transformed into a digital image. Second, different construction aggregate particles in the digital image are isolated so that the data for each particle can be processed individually. Finally, each particle's data are analyzed to produce such shape properties as particle size distribution (gradation), elongation ratio, flatness ratio, angularity, and texture. Verification tests show that this approach characterizes the aggregate properties in a fast, accurate, and reliable way.