**Solicitation Detail View**

Utilization of Laser Induced Breakdown Spectroscopy (LIBS) for Real-Time Testing and Quality Control Monitoring of Aggregate Materials used in Highway Construction

**General Information**

Lead Agency: Kansas Department of Transportation

**Financial Summary:**

Commitment Start Year: 2016 Commitment End Year: 2018

Commitments Required: $993,130 Commitments Received

**Study Description**

**Background:**

The need for upgrading aggregate quality control (QC) test methods in the highway construction industry has been apparent for many years. Many of the current aggregate QC test methods are time consuming, highly inefficient and provide considerable risk to the hot mix asphalt and Portland cement concrete production industry. Hot mix asphalt and Portland cement concrete suppliers generally produce and laydown final pavement products prior to receiving quality control testing results. The ramifications of test failures after the pavement is in-place is financially and administratively burdensome to the producers, contractors and the transportation agencies charged with ensuring that funds to construct and maintain the highway infrastructure are used efficiently. QC issues in the industry are further aggravated by the poor precision associated with many of the sampling and acceptance tests employed by the industry and the skill of technicians conducting such tests.

The proposed TPF Phase II continues and finalizes the pooled funded laser scanning research investigation (TPF 5[278]) that began on June 1, 2013 with five participating State Agencies: KS, NY, OH, OK, and PA and allows aggregate testing to additional State Agencies wanting to take part in this study. This solicitation continues the work and success of the NCHRP 150 Proof of Concept Study, the NCHRP 168 prototype developmentand the current TPF-5(278) which has shown the potential and success of this technology. Reports from these studies are included in the Documents Section.

**The Process and System:**

The process makes use of a high-powered laser that targets and vaporizes a small portion of the aggregate particle inducing a light emission that is captured by an internal spectrometer. This light emission (emission of electromagnetic radiation) provides a unique wavelength pattern that contains useful information about the atomic, elemental and mineral content of the aggregate. Using this wavelength pattern, it is possible to “fingerprint” aggregates based on the specific wavelength pattern associated with the laser induced emission. The whole process is referred to in the scientific literature as Laser Induced Breakdown Spectroscopy (LIBS). Once a “fingerprint” is made of an aggregate of known quality or type, it is possible to document that fingerprint and use it as the basis for determining whether an unknown aggregate is the same as the known aggregate. By developing a “database of aggregate fingerprints” with varied properties, it is further possible to classify an unknown aggregate by comparing it to the known database to determine which aggregate material (fingerprint) it most closely resembles. By doing so, the aggregate source location can be verified and stockpiles can be verified as being composed of only previously approved aggregate. It is also possible to calibrate aggregate “fingerprints” to enable the quantitative prediction of engineering properties such as specific gravity, acid insoluble residue, MicroDeval loss, etc.

The system developed for aggregate scanning using the LIBS process is described in detail in the NCHRP 168 report. It is referred to as the Sampling and Laser Targeting System (SLT). The first SLT prototype is currently in operation at a quarry site in South Bethlehem, New York and is showing very good results and positive trends in predicting engineering properties.

**Objectives:**

The overall objective is to upgrade QC/QA in the industry by developing a real-time laser scanning system to rapidly classify aggregates used in highway construction. The intent is to employ this classification process to

* Quantify specific engineering properties (e.g., specific gravity, acid insoluble residue, Microdeval loss, etc.),
* Assess whether an aggregate source will pass or fail a defined engineering property test,
* Identify and/or quantify the presence of deleterious materials (e.g., reactive aggregates, cherts, etc.),
* Determine whether aggregate composition or quality is changing during production, and
* Determine the source material or sources of blended production materials.

An aggregate laser scanning system has the potential to be employed in private and government material testing laboratories, where laser scanning of aggregate samples can be undertaken, providing multiple engineering parametric results in near real time.

**Scope of Work:**

The scope of work includes continued development of the laser scanning system, data analysis software and an expanded testing effort to enlarge the database with the current participating Agencies and the addition of new State Agencies. The anticipated tasks in this effort are:

1. Sample Collection, Scanning and Modeling of Test Parameters:

Aggregate samples along with laboratory testing results shall be supplied by participating Agencies for laser scanning and modeling activities. Aggregates will be fingerprinted and engineering property prediction models created as specified by each Agency.

1. Hardware, Software and Data Handling, and Modeling Modifications:

Methods for improving material flow, laser focusing, data processing, data modeling will be incorporated into the effort as needed to improve spectral output resolution and improve model prediction.

1. AASHTO Standard of Practice:

Work on the preparation (in coordination with the AASHTO Subcommittee on Materials Testing) of a Standard Test Method for using a laser scanning system as an aggregate testing method. A draft of this practice was prepared as part of the NCHRP 168 final report.

1. Project Management, Reporting and Annual Review Meetings

The Principal Investigator shall coordinate all technical and administrative activities amongst the Participating Agencies and the Research Team. One representative from each participating Agency will be designated the Agency Project “Representative”. Travel for annual review and planning meetings is provided (up to $2000 per year per agency) by the project funding.

1. Technology Transfer Meeting: Each state shall have the option of scheduling a Technology Transfer Seminar at a designated in-state location for State DOT staff, University Staff and Student Training to be presented by the Research Team personnel.

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**Comments:**

We are seeking 7 partners to contribute $48,000 per year for three years. In addition, we encourage funding from associations, testing centers and other organizations of the aggregate and highway construction industries.

100% SPR Funding has been requested.

Deliverable:

Report, prepared for on-line publication that will present the use of LIBS technology (and associated equipment) for quality control monitoring of aggregate in highway construction industries to include but not be limited to a description of techniques and methods for

• Fingerprinting aggregates for use in real-time testing for aggregate source location (verification that approved aggregate is being used),

• Real-time accurate prediction of engineering properties (pass/fail prediction of aggregate for specific engineering properties),

• Using an agency “aggregate fingerprint” database for use in aggregate acceptance eliminating the need for repeated costly and lengthy laboratory testing methods currently in use,

• Final-Draft of AASHTO Standard of Practice for use of technology for aggregate QC monitoring

• Data from all locations analyzed during the course of the investigation (available for participating states)   
• Results may be published in peer review research journals as appropriate

**Documents**

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| **Title** | **Type** | **Private** |
| NCHRP 168, September 2015---Prototype Development: Automated and Continuous Aggregate Sampling and Laser Targeting System | Report | N |
| NCHRP 150, April 2012---Automated Laser Spectrographic Pattern Matching For Aggregate Identification | Report | N |

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