REQUEST FOR PROPOSALS
Field Implementation of Handheld FTIR Spectrometer for Polymer Content Determination and for Quality Control of RAP Mixtures
LTRC Project No. 17-1B, SIO No. DOTLT1000161

PROBLEM STATEMENT

The Louisiana asphalt industry is continually exploring methods to make asphalt more environmentally friendly, less wasteful, more efficient, and better performing. The industry is responding by recycling old asphalt and adding more modifiers to asphalt binders and emulsions. The addition of recycled asphalt or modifiers blended with virgin binders can result in a severe change of the properties and characteristics of the newly modified asphalt binder. It is important for Louisiana transportation engineers and researchers to understand the physical and chemical makeup of recycled and modified binders because inconsistency in quantities of materials added can result in performance fluctuations. Several testing devices are used to screen the contents of asphalt binders. Test devices such as Gel Permeation Chromatography (GPC), Dynamic Shear Rheometer (DSR), Elastic Recovery (ER), Ductility Test and Multiple Shear Creep Rheometer (MSCR) can consistently construct a fingerprint of asphalt binders. However, these devices have to be performed in a lab setting and require several hours to days to perform. With the stringent construction timelines of transportation agencies and contractors, researchers are looking at implementing the Fourier Transform Infrared (FTIR) Spectrometer as a tool to determine physical and chemical content of asphalt binders. The FTIR spectrometer has the advantage of being faster, easier to handle, and inexpensive than the aforementioned testing devices, but requires further researching of its capabilities.

OBJECTIVE

The purpose of this research project is to determine if the FTIR can be implemented in Louisiana for polymer content determination and for quality control of recycled mixtures. The FTIR spectrometer has the advantage of being faster, easier to handle, and inexpensive than current testing methods, but requires further researching of its capabilities. The FTIR will need to be tested for precision of results, testing time, and cost effectiveness versus the other asphalt binder testing devices.

RESEARCH APPROACH

The Louisiana Transportation Research Center (LTRC) is seeking the insight of proposers on how best to achieve the research objectives. Proposers are expected to describe research plans that can be realistically accomplished within the constraints of available funds and contract time as allowed in this RFP. Proposals must present the candidate's current thinking in sufficient detail to demonstrate their understanding of the problem and the soundness of their approach. Task descriptions are intended to provide a framework for conducting the research. The proposal shall address at a minimum, the following tasks:

Task 1 – Review of Literature and State-of-the-Practice

Conduct a comprehensive literature review of previous research completed on the FTIR spectrometer specifically used for the asphalt industry. Sources of information include, but

are not limited to, National Cooperative Highway Research Program (NCHRP) reports and Transport Research International Documentation (TRID).

Task 2 – Equipment Selection
Describe commercially available FTIR equipment and propose selection of FTIR equipment to the Project Review Committee (PRC). **The PI may not proceed with purchase of an FTIR device without written approval from the LTRC Project Manager.**

Task 3 – Experimental Plan
Create a clear description of experimental plan. The experimental plan should detail the appropriate laboratory, and/or field, testing appropriate to fully evaluate the FTIR technology.

Task 4 – Data Analysis
Detail proposed data analysis procedures and description of any analytical software intended to be used in completion of the research project. The data analysis should include precision and bias techniques (where applicable), which will be beneficial to the implementation of FTIR into QC practices.

Task 5 – Final Report, Recommendations, and Implementation Plan
The research team will prepare a final report to document the entire research effort. The final report should include all the data, results, and recommendations generated by this study. The implementation plan is a separate document that describes how the department should enact the recommendations within the specifications, and policies of DOTD.

DELIVERABLES
The proposal shall include project deliverables for appropriate tasks. Deliverables shall be due as defined in the proposal. The proposal shall include at a minimum the following deliverables:

- Equipment recommendation (Task 2)
- Final Report, Technical Summary, Summary Presentation, Recommendations, and Implementation Plan (Task 5)
    - The researcher shall provide a final report that documents the entire research effort. A Final Draft Report, Technical Summary document (two pages), and summary presentation to the PRC are due three (3) months prior to the project completion date for review and approval. The final report shall direct and recommend future steps toward the incorporation/implementation of the research results into department policy, and include recommendations on other areas that could be further expanded in subsequent research projects.

SPECIAL NOTES

A. LTRC research projects will be conducted in accordance with the LTRC Manual of Research Procedures, 2016 edition. (http://www.ltrc.lsu.edu/pdf/2016/LTRC_RESEARCH_MANUAL_FINAL.pdf)
B. Any work that is anticipated to be required from LTRC or DOTD shall be specifically

detailed in the proposal.

C. Any surveys or questionnaires developed by the research team shall be reviewed and approved by the PRC prior to distribution.
D. LTRC projects are intended to produce results that will be applied in practice. It is expected that the implementation of the results of this research into practice will evolve as a concerted effort during this project. The final report must contain an implementation plan to include, as a minimum, the following:
    a. The "product" expected from the research;
    b. A realistic assessment of impediments to successful implementation;
    c. The activities necessary for successful implementation; and
    d. The criteria for judging the progress and consequences of implementation.
E. To assist in the implementation process, the investigators of this research shall present the final results to LA DOTD officials in an oral presentation to be held in Baton Rouge, Louisiana at LA DOTD Headquarters after acceptance of the final report.
F. The proposal should include travel to meet with the Project Review Committee for a "kick off" meeting, presentation of interim report, and presentation of the final report at a minimum. Funds budgeted for travel shall be limited to what is necessary for the conduct of the research. Funds shall not be budgeted for conference travel. Funding for technology transfer of research results are available upon request subject to LTRC approval and available funds.
G. LTRC's mission includes the support of higher education in Louisiana. Consultant and out-of-state institutions submitting proposals are encouraged to cooperate and collaborate with Louisiana universities for the purpose of sharing of knowledge and increasing transportation expertise in the academic community.
H. Graduate assistance stipends are allowed. Tuition reimbursement or tuition remission rates applied to stipends are not allowed.
I. To equitably answer any questions regarding this Request for Proposals, the Louisiana Department of Transportation and Development (LA DOTD) website will be updated with questions and answers and related documents regarding the project. http://webmail.dotd.louisiana.gov/agrestat.nsf/WebAdvertisements?OpenPage
LA DOTD makes these documents available for informational purposes only to aid in the efficient dissemination of information to interested parties. LA DOTD does not warrant the documents against deficiencies of any kind. The data contained within this web site will be periodically updated. Interested parties are responsible to be aware of any updates. Questions regarding this RFP should be submitted in writing to the LTRC contact person. Questions must be received by close of business seven calendar days prior to deadline date.
J. Consultants and business entities shall be registered with the Secretary of State in order to be able to work in Louisiana prior to award of contract. http://www.sos.la.gov/tabid/1011/Default.aspx
K. If Sub-Consultants/Entities are used, the Prime Consultant/Entity must perform a minimum of 51% of the work for the overall project.
L. LTRC reserves the right to withhold invoice payments for delinquent deliverables as defined in the proposal.

ESTIMATED COST OF RESEARCH
$200,000

ESTIMATED COMPLETION TIME
24 Months *(includes 3 months for review and approval of final report - i.e. final report due 21months)*

LTRC PRIMARY CONTACT
Samuel Cooper, III, Ph.D., P.E.
LTRC, Materials Research Administrator
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AUTHORIZATION TO BEGIN WORK:
February 1, 2017 (estimated)

PROPOSAL FORMAT
All proposals are required to be formatted according to LTRC Manual of Research Procedures. Section 3.3 provides guidance on proposal development. A copy of the Manual may be downloaded from our website (http://www.ltrc.lsu.edu/pdf/2016/LTRC_RESEARCH_MANUAL_FINAL.pdf).

PROPOSAL SELECTION
The Project Review Committee selected for this project will review, evaluate and rank all proposals received using the criteria established on the attached proposal review form.

DEADLINE FOR RECEIPT OF PROPOSALS
Ten copies of the proposal must be received by LTRC by the close of business day of January 15, 2017.

Proposals should be submitted to:
Dr. Samuel Cooper Jr., Ph.D., P.E.
Director
Louisiana Transportation Research Center
4101 Gourrier Ave.
Baton Rouge, LA 70808

APPENDIX

Background of Fourier Transform Infrared (FTIR) Spectrometer

The FTIR spectrometer is a rapid non-destructive technique that requires minimal sample preparation and minimal training of operators. It has additional advantages of being field portable and inexpensive compared to other characterization methods. The second Strategic Highway Research Program (SHRP2) has suggested the FTIR spectrometer be used in testing recycled and modified asphalt binders primarily for determination of polymer content quantities in asphalt binders. Additionally, several researchers (Yildirim 2007) (Nasrazadani, et al. 2010) have found the FTIR to be a good tool for quality control of modified and recycled asphalt.

The FTIR analytical tool provides information about the chemical bonding or molecular structure of materials, whether organic or inorganic. It is used to identify unknown materials present in a specimen. The technique works on the fact that bonds and group of bonds vibrate at characteristic frequencies which are characteristic to that molecule. During FTIR analysis, a spot on the specimen is subjected to a modulated IR beam. The specimen's transmittance and reflectance of the infrared rays at different frequencies is translated into an IR absorption plot consisting of reverse peaks. The resulting FTIR spectral pattern is then analyzed and matched with known signatures of identified materials in the FTIR library collection. The FTIR library contains a large collection of organic and inorganic compounds used in paving materials which makes analysis and interpretation of FTIR spectra relatively easy (Nasrazadani, et al. 2010). An example of FTIR absorption bands are shown below in Table 1.

Compound	Assigned band (cm-1)	Origin
PS	699 and 750	C – H oop* bending in monoalkylated aromatic
PB	993	C – H oop bending of cis-alkene
	966	C – H oop bending of trans-alkene
	911	C – H oop bending of terminal-alkene
	730-650	C – H wagging of cis-alkene

*oop = out of plane

FTIR for Asphalt Polymer Content

Modifiers for asphalt binders and emulsions can take form as polymers, rubbers, latex, or various chemical additives. When blended with asphalt binders or emulsions, they have the ability to reduce rutting, thermal cracking, fatigue damage, stripping, and temperature susceptibility (Yildirim 2007). However, modifiers can have a certain degree of variability in the quality and uniformity used in processing and production of these products. This variability in polymer content can result in poor performing asphalt which makes it is important for contractors and transportation departments to know the accurate amount of polymer content in the binders. Research done by Nasrazadani et. al. (Nasrazadani, et al. 2010) found FTIR is capable of differentiating between polymer and non-polymer-modified binders. Asphalt samples with known SBS content from multiple suppliers were used to generate calibration curves for polymer quantification. Calibration curves showed a linear relationship between band area ratio (966 cm^{-}

^{1}/1375 cm^{-1}) and polymer weight percent (as described in AASHTO T 302-05) with R^2 values close to 1.0. According to Lu et. al. (Lu, Gunaratne and Guo 2015)

FTIR for Recycled Asphalt Pavements

The use of reclaimed asphalt pavement (RAP) in new pavement mixtures is an important topic for the transportation industry due its economic and environmental implications. RAP is generated when asphalt pavements are removed for reconstruction, resurfacing, or to obtain access to buried utilities. The RAP is then reused and blended with virgin materials at the asphalt plant. There is concern, however, about how well the binder from the RAP blends with the virgin binder when the mixture is created. Insufficient blending of the aged and unaged binders may compromise the long-term pavement performance. RAP is normally tested by separating the binder from the aggregate through extraction test methods. The binder is then normally tested using several asphalt binder test such as the DSR, MSCR, Elastic Recovery, and Ductility Bath. This process of examining the polymer content can take several hours to days which can put a strain for the timely driven asphalt construction industry. A field portable FTIR spectrometer can assist in quality control of RAP mixes by comparing field RAP content with the mix design (target) RAP content. The FTIR requires no extraction of binders which can save quality control testing time.