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Technology and Innovation Deployment Program
STIC Incentive Application Form

Proposal Name: Integration of Temperature Profile with Intelligent Compaction (IC)

STIC/State Name: Oklahoma	**FY:** 2020

Innovation: (Describe the innovation that the state is looking to implement on a statewide basis including the purpose and benefit to the state.)

Performance of asphalt pavements depends on the quality of construction of individual asphalt layers or mats. Inadequate compaction is a leading cause for the early deterioration of asphalt pavements. Asphalt cores as an indicator of construction quality are not reliable because they typically cover less than 1% of the constructed pavement. Intelligent compaction (IC) estimates the level of compaction of entire pavement layer during construction. IC rollers are equipped with temperature sensor that measures surface temperature of the asphalt mat which does not reflect the actual temperature within the mat because of spraying of water by the roller, ambient moisture, wind and other factors. Temperature data from several IC pilot projects, processed by the OU team under a Task Order from ODOT using the VETA software, show that a notable percentage of the asphalt mat did not meet the ODOT's minimum temperature requirement. Using surface temperature data from the roller is believed to be a major factor in this regard. Also, thermal imaging data from MOBA are not currently integrated with the quality of compaction such as coverage, number of passes and ICMV values. In addition to using MOBA data to chek segregation of asphalt mix, they can be an useful indicator of quality if integrated with other IC parameters such as coverage, number of passes and ICMV values.

In the proposed project, surface temperature will be correlated with the temperature profile of the asphalt mat (i.e., variation of temperature within the mat) and used in VETA to check temperature compliance and compaction quality. Also, the temperature data from MOBA (or other temperature senors mounted behind the paver) will be integrated with the temperature profile of the mat and used to check compaction quality as measured by coverage, number of roller passes, and ICMV. GPS data from paver and compactor will be used in this integration. Integration of temperature profile with IC will be an important step forward in montoring compaction quality of entire mat and reduce (and eventually eliminate) the need for taking cores, which is a destructive process.

Description of the Proposed Work: (Describe the scope of work that is to be completed with this funding request, whether this is a complete project or part of a larger phased project, how it will have a statewide impact in making the innovation a standard practice in your state. Only include work that is eligible for STIC Incentive funding.

IC rollers are equipped with accelerometers for measuring vibration, a GPS for monitoring spatial location, a temperature sensor for measuring surface temperature and an on-board computer for real-time execution of software and data storage. The IC technology is based on the principle that the vibratory roller and the underlying pavement form a coupled system whose response during compaction is influenced by the stiffness of the pavement layers. The GPS data is used to determine the coverage (number of roller passes) for the entire pavement. Surface temperature of the asphalt mat does not reflect the actual temperature within the mat because of spraying of water by the roller, ambient moisture, wind and other factors. To remedy this problem, in the proposed study, both IC data and temperature data will be collected from at least three construction projects. The temperature data will consist of laydown temperature from MOBA (an IR-based scanner mounted behind the paver) and temperature from thermal sensor mounted on the roller. In addition, temperature at different depths within the mat (at half-an-inch interval) will be measured using a temperature probe to determine the thermal profile of the mat. The thermal profile will be correlated with the surface temperature obtained from the compactor using a thermodynamic model or a statistical approach. Also, the thermal data from MOBA will be integrated with the compaction temperature data using GPS coordinates. Thermal imaging map, coverage map, and ICMV map, all obtained from VETA, will be used for visual comparison of these factors on compaction quality. Statistical distributions of these factors may be used for numerical comparisons. Our industry partner, Silver Star Construction Co., will provide access to construction site, IC tools (Topcon, MOBA, VETA), and collection of data (see attached letter of support).

The specific tasks of this study are listed below:
Task 1: Review different intelligent compaction (IC) and thermal imaging technologies; the review may be focused on TOPCON and ICA (Intelligent Compaction Analyzer). Also, review and understand ODOT special provision for IC.
Task 2: Select three construction projects in collaboration with ODOT and Silver Star Construction Co.
Task 3: Collect IC data from each site, including surface temperature data using thermal sensor mounted on the roller. Measure temperature at different depths (0.5-inch interval) within the asphalt layer using temperature probe with digital readers, after each roller pass. Use these data to determine thermal profiles. Record GPS coordinates of locations where temperature readings are taken.
Task 4: Establish correlations between surface temperature and temperature profile using thermodynamic/statistical model(s) using data in Task 3.
Task 5: Collect laydown temperature data using MOBA and project layout (from GPS) for each project, and identify locations where temperature profile data are taken. Determine the variation of compaction temperature profile with the number of roller pass.
Task 6: Analyze IC data using VETA software as a function of number of passes, temperature, and ICMV.
Task 7: Collect field cores from well-compacted and under-compacted areas based on the IC data and thermal profile.
Task 8: Conduct volumetric (air voids, density) tests on field cores and compare with ICMV values.
Task 9: Prepare a final report and conduct a workshop. The findings may be used to revise ODOT special provision or guidelines for IC.

End Product: (Identify what the final deliverable will be when the project is complete. Include the Expected Outcomes, Benefits and/or Results)

(i) Correlation between surface temperature and temperature profile (variation of temperature within the asphalt mat); (ii) Influence of laydown temperature, compaction temperature and distance between paver and compactor on compaction quality; (iii) Recommendations for updating existing ODOT special provision (Section# 411-18) on intelligent compation; (iv) Improved tool for monitoring compaction quality of entire asphalt mat during constraction.

Proposal Schedule: (Anticipated start date and when will product be delivered? The anticipated project schedule is required. The schedule should show how the work will be advanced in the fiscal year for which the funds are being requested, and the anticipated completion date of the work. This should directly reference each line item in the cost estimate. Applications should only be submitted for projects that are ready to advance if the minimum partial funding request is met.)

The schedule for Year 1 of this study is as follows:

Task No.	Duration (Month)								
	1	2	3	4	5	6	7	8	9
1									
2									
3									
4									
5									
6									
7									
8									
9									

Champion(s): (Who will be reporting progress on this work to the state STIC? Progress Reports are to be provided to FHWA every 6 months, with a Final Report at conclusion of work.)

Musharraf Zaman, Professor of Civil Engineering and Professor of Petroleum and Geological Engineering, will be responsible for the overall execution of the study in a timely manner, and for ensuring a successful outcome. He is a highly accomplished researcher and has successfully obtained and directed a large number of projects (worth more than $30 million), including some highly competitive national-level projects. He will have a key role in preparing the final report.

Syed Ashik Ali, a senior doctoral candidate in Civil Engineering, will be responsible for planning and collecting IC data and thermal profile data. He will analyze the IC and thermal profile data and establish correlations. Also, he will be responsible for preparing the progress reports and the final report and in making recommendations for updating the special provision.

Estimated Total Cost: $59,280	**Amount of STIC Funds Requested:**	$49,400

Estimated Total Cost/Budget Breakdown: (Provide a cost estimate that is reflective of the total cost of the proposed work by line item. Each line item should be associated with a completed task, deliverable, or outcome that contributes to the completed funding request. In the event that partial funding is available, this information will aid in the development of funding recommendations and provide the applicant the opportunity to fully complete individual components of the funding request. If the applicant is willing to accept partial funding of the request then that should be indicated as well.)

The total estimated cost of this 9-month study is $59,280, including F&A or indirect cost (IDC). Of the total estimated amount ($59,280), $49,400 is requested from the STIC program and $9,880 is expected to be provided by the ODOT SP&R program.

Personnel: Dr. Musharraf Zaman will lead the proposed study and be responsible for its execution in an efficient and timely manner. The budget includes $3,500 for Dr. Zaman to support his role in this project. Mr. Syed Ashik Ali, a senior doctoral candidate, will be responsible for planning and collecting IC and thermal profile data, collecting these data, establishing correlations and preparing monthly progress reports and final report. The budget includes $18,000 for Mr. Ali @$2,000/month for 9 months to support these activities. An undergraduate research assistant (URA) will be appointed to assist Mr. Ali with field data collection and analysis using VETA. The URA will also help in developing correlations. The URA is expected to work about 15 hours per week for 9 months @ $15/hour. The budget includes $8,100 for the URA to support these activities.

Fringe Benefits: The fringe benefit rates used herein are consistent with the rates OU charges to funding agencies. The following rates are used: faculty and other professional – 41.20%; undergraduate student (intern) - 0.30%, graduate student (intern) – 12.80%.

Travel: Travel support of $1,000 is requested to cover field trips for collection of IC data from each of the three construction projects, coring, and other travels directly related to this project.

Equipment and Supplies: Funds are requested in the budget for the digital temperature probe ($1,500) and for expendable laboratory supplies ($500).

Other Expenses: The budget includes $250 for computer supplies (data storage, cartridge, papers, etc.) and copying of workshop materials ($125). The budget also includes workshop costs ($500).

IDC: Based on the OU rate, the indirect costs of 55% are used in estimating the overall cost. The budget for the proposed study is as follows:

Source of Other Funds or Sponsors: (20% match required. Indicate the amounts and sources of any private or other public funding and/or third party in-kind services being provided as part of this project. Only indicate those amounts of funding that are firm and documented commitments from the entity controlling the funds.)

Of the total estimated amount ($59,280), $49,400 is requested from the STIC program and $9,880 is expected from the ODOT SP&R program. In view of the task-oriented nature of this project, the ODOT SP&R amount may be covered by the Task Order Agreement with OU. The OU team has shared this proposal with Kevin Suitor, Scott Garland and Waseem Fazal, as well as with Larry Patrick. The OU team plans to work with ODOT, FHWA, and OAPA to revise the proposal so that it better suits the agency and industry needs. Also, Silver Star Construction Co. has agreed to support this study (see the attached letter of support).

Silver Star
Construction Co., Inc

2401 S. Broadway - Moore, Oklahoma73160 – (405) 793-1725 / 1-800-375-1725 / Fax (405) 793-9989

Program Coordinator
Center for Accelerating Innovation
State Transportation Innovation Council (STIC)
Oklahoma Department of Transportation

June 28, 2019

Dear Program Coordinator:

It is with great pleasure we partner in the proposed study with the University of Oklahoma for possible funding from the State Transportation Innovation Council (STIC). Our company has been working with Dr. Zaman and his team on the implementation of intelligent compaction (IC) technology. Our involvement in intelligent compaction started with the purchase of TOPCON - one of the IC technologies included in the proposed study for implementation. Since then we have used this unit in multiple construction projects. We have recently purchased an IR-based thermal imaging system, MOBA, for monitoring of asphalt mat temperature behind the paver. As discussed in the proposal, we have observed in the field that the quality of compaction depends on the compaction temperature of the asphalt mat. The integration of real-time compaction information with the thermal profile data from IR scanner will be instrumental to the evaluation of the effect of compaction temperature on the properties (density and air void) of constructed pavements. We believe the proposed study will enhance our understanding on the compaction of asphalt layers during construction and will aid in developing the best practices for roller operation to achieve desired density and coverage. Therefore, we are strongly supportive of the proposed study, and are committed to providing the matching funds. Specifics of our commitment are given below.

Our matching support will be provided as in-kind ($12,000) in the form of constructing three test sections and monitoring of compaction quality using both TOPCON and the Intelligent Compaction Analyzer (ICA). MOBA data will also be collected from each site. Each test section will be at least half-a-mile long and have a width of one lane. Our company will provide the materials, equipment, paving crew, traffic control and logistic support. Because some test sections will involve construction of multiple layers of asphalt, the actual construction cost would be much more higher.

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We believe the topic is important and timely, not only for our company but for other companies in the state. We are committed to working with Dr. Zaman and his team to successfully complete the proposed study. We hope that Oklahoma STIC will extend their support for this exciting and timely study.

Sincerely,

Craig Parker
President, Silver Star Construction Co.