January 30, 2014

National Center for Asphalt Technology NCAT at AUBURN UNIVERSITY

Minnesota Department of Transportation
Office of Materials and Road Research
MnROAD Test Facility

STATEMENT OF WORK

Project Title
NCAT and MnROAD Partnership to Address National Needs for Research in Pavement Preservation and Asphalt Mixture Performance Testing

Principal Investigators
Dr. Raymond "Buzz" Powell, P.E.
Phone: 334-844-6857
Email: buzz@auburn.edu

Mr. Ben Worel, P.E.
Phone: 651-366-5522
Email: Ben.Worel@state.mn.us

Background
The NCAT Pavement Test Track was originally constructed as a result of interest and support from state Departments of Transportation (DOTs) who shared a concern for building and maintaining safe and cost effective pavement infrastructure. Forty-six 200-ft test sections are subjected to 10 million equivalent single axle loadings (ESALs) of heavy truck traffic compressed into two years of fleet operations on the 1.7-mile closed oval. Test pavements are rebuilt every three years to facilitate a new research cycle in which sponsors can focus on mill/inlay research on perpetual pavements, structural research, or pavement preservation.

The NCAT Pavement Test Track will be rebuilt in the summer of 2015 to facilitate the 6th research cycle. Data collection will continue on off-Track pavement preservation sections placed on Lee Road 159 in the summer of 2012, and new higher traffic pavement preservation sections will be placed on nearby US-280. Both test roads will be used to further define the life extending and condition improving benefits of pavement preservation treatments and treatment combinations.

NCAT is partnering with MnROAD for the first time in the 2015 research cycle to execute pavement preservation and asphalt mixture performance testing experiments with a nationwide implementation impact. Research sponsors will have decision making authority on the targeted use of the funding they provide, meaning that states can choose which facility (either NCAT or MnROAD) will be the focus of their research investment. It is expected that many treatments/pavements will be studied at both locations. Background information on the scope of the NCAT/MnROAD partnership is provided as an attachment. Positive experiences with implementable findings that reduce the life cycle costs of pavements and facilitate rapid deployment of sustainable technologies have made past research at both NCAT and MnROAD an outstanding investment for numerous state DOTs. The partnership is expected to synergize

the yield and broaden the scope of implementable findings, while at the same time expand the capabilities of both facilities on complementary research through close collaboration.

Sponsorship Options

The 2015 NCAT Pavement Test Track is expected to consist of structural experiments, mill/inlay surface mix experiments, and pavement preservation studies (both at NCAT and at MnROAD). Sponsors will include highway agencies and private sector partners. Sponsors are encouraged to choose experiments that meet their specific research needs. Individualized test sections will still be optional in the 2015 research cycle. The NCAT/MnROAD partnership team will work with sponsors to develop group experiments that address common needs that will include test sections at NCAT, MnROAD, and on public roadways both in Alabama and Minnesota.

Preservation Group

The Preservation Group (PG15) study is designed to encompass timely issues that are important to the pavement community. Five sections from the 2009 Group Experiment (GE) survived the previous two traffic cycles. Select preservation treatments were installed in the spring of 2014 when predetermined distress levels were reached. Funding for the PG15 study will provide continued traffic and monitoring of these sections in order to fully quantify the life extending benefit of the pavement preservation treatments.

NCAT also placed 23 preservation treatments on Lee Road 159 in the summer of 2012. This county road provides dead end access to a quarry and an asphalt plant. Truck loading from these two operations is provided to document the traffic on the preservation treatment sections. Regular testing by NCAT documents roughness, rutting, macrotexture, cracking, and structural integrity of each section as a function of traffic, age, and seasonal effects. As part of the PG15 study, the research on Lee Road 159 will be extended into the new (2015) research cycle.

Additionally, new pavement preservation treatment sections will be built in 2015 on nearby US-280, which is a higher ADT, more diverse load spectra route. The purpose of the new sections on US-280 will be to quantify the life extending benefits of pavement preservation on a more typical highway in between the accelerated damage environment of the NCAT Pavement Test Track and the low ADT environment of Lee Road 159. The treatment sections will be 0.1 miles in length and may include treatments and treatment combinations such as:

- Chip seals (single, double, and triple layer);
- Scrub seal;
- Micro surface;
- Cape seals (conventional, HMA, FiberMat, and scrub);
- Thin asphalt overlays (virgin and mixes with RAP & RAS);
- CIR (foam & emulsion), CCPR (foam & emulsion), and HIR under thin overlays; and
- Fog seals (with and without rejuvenators).

The actual preservation treatment sections will be selected by the PG15 sponsors. Consensus treatments will be selected by sponsors for placement at the MnROAD facility and on other high and low volume roadways in Minnesota.

Results from the expanded PG15 experiment will provide a rational starting point for the implementation of a life cycle cost-based preservation treatment selection process that can be refined over time with location-specific pavement performance feedback. The other objective of the PG15 experiment is to develop guide specifications and recommend guidelines for quality assurance testing/inspection of pavement preservation treatments.

Cracking Group

The Cracking Group (CG) is the second focus area in the 2015 research cycle for both NCAT and MnROAD. The objective of the CG experiment is to validate laboratory cracking tests by establishing correlations between the test results and measured cracking in real pavements (test sections). This experiment will require the construction and trafficking of a series of new test sections with asphalt mixtures that have a range of expected cracking susceptibilities. All other factors that can impact cracking, such as layer thicknesses and underlying layer stiffnesses, will be controlled to the highest degree possible. A battery of laboratory cracking tests will be conducted on mixes to identify which test results best correlate with field cracking. The following tests have been suggested for inclusion in the 2015 CG study, with the actual methods determined by consensus among agencies that choose to participate:

- Indirect tensile work;
- Bending beam fatigue;
- Simplified viscoelastic continuum damage;
- Disc-shaped compact tension test;
- Semicircular bend test; and
- Texas overlay tester.

The analysis of the laboratory cracking tests will also consider its variability, utility and practicality of implementation for both mix design approval and quality control testing.

Objectives

The primary objectives of the pooled fund project described herein will be:

1. Constructing test sections on the existing 1.7 mile NCAT test oval and on an off-Track high ADT roadway that are representative of in-service pavements on the open transportation infrastructure. Additionally, select sections will be constructed at the MnROAD facility and on other roadways in Minnesota;
2. Applying accelerated truck traffic to the NCAT test oval for approximately two years in a highly controlled and precise manner. Additionally, post construction traffic will be carefully documented on off-Track sections and the MnROAD facility for the duration of the 3-year research cycle;
3. Assessing/comparing the functional and structural field performance of trafficked sections on a regular basis via surface and subsurface measures;
4. Validating/calibrating new and existing M-E approaches to pavement analysis and design using pavement surface condition, pavement load response, precise traffic and environmental logging, and cumulative damage;
5. Quantifying the life extending benefit of various pavement preservation alternatives as a function of pretreatment condition in a highly controlled experiment that will provide state DOTs with the objective foundation to implement a decision tree for their own maintenance program. These types of programs are then refined over time using actual pavement management performance data;
6. Correlating field performance with laboratory results and developing rational test criteria for possible specification use; and
7. Answering practical questions posed by research sponsors through formal (i.e., reports and technical papers) and informal (e.g., one-on-one responses to sponsor inquiries) technology transfer. For example, can the same laboratory tests be used to screen both

virgin and high binder replacement (i.e., higher RAP and RAS) mixes for cracking susceptibility for both mix design approval and quality control test applications?

Scope of Work

The scope of work for the pooled fund project will include:

1. Hauling materials to the project from offsite locations. Material donations are typically secured by state sponsors, while reasonable hauling expenses are handled by the pooled fund;
2. Rebuilding sections in accordance with sponsors' directives via competitively bid subcontracts administered by NCAT. It is anticipated that equipment rental, aggregate hauling, liquid asphalt supply and delivery, plant production, and mix placement may all be procured via competitively bid subcontracts. Additional preservation treatment sections will be applied to a nearby highway as well as at the MnROAD test facility;
3. Installing both environmental (i.e., multi-depth pavement temperature probes) and response instrumentation (e.g., high speed stress and strain gages) in new experimental sections;
4. Operating a 5-truck heavy triple-trailer fleet on the NCAT test oval in order to apply accelerated truck traffic following the completion of construction. Actual human drivers operate the vehicles in order to provide realistic vehicle wander;
5. Measuring field performance each week when the fleet is parked to fully document the changes in surface condition as a function of traffic and temperature. High-speed pavement response will also be measured on a weekly basis in structural sections. Surface friction will be measured on a monthly basis. Performance will be measured on off-Track pavement preservation sections on at least a monthly basis;
6. Conducting laboratory testing to quantify basic material and mix performance properties, which will serve as the basis of performance model development; and
7. Comparing predicted and measured pavement response as well as predicted and measured cumulative pavement damage in order to validate then calibrate prevailing M-E methodologies and to quantify the life extending benefit of various pavement preservation alternatives.

Work Plan

"Phase I" laboratory testing to aid in the test section planning process will begin in the fall of 2014. Preparations to rebuild the Track will begin in March of 2015. Construction of new experimental pavements is expected to begin in mid-2015. Truck traffic on the NCAT test oval will begin in October 2015 and will be complete by the fall of 2017. Documentation of traffic and performance on off-Track sections and at the MnROAD facility will begin as soon as pavement preservation sections have been placed and continue until the end of the 3-year research cycle. A draft final report will be prepared and distributed to research sponsors for review by March 2018. The final report will be published by the summer of 2018 after responding to sponsors' feedback.

Implementable Findings

Standalone research (either in single test sections or multiple sections of similar design and construction) will provide state DOTs with confidence to improve specifications in accordance

with experimental outcomes. A battery of laboratory tests will be run on actual plant run materials to provide a baseline for field correlations and validate future performance characterization methodologies. Surface performance sections can be used to approve new mix materials/methods, improve specifications, or solve existing performance deficiencies in a highly controlled environment. Structural performance sections can be used to accomplish many of the same objectives as surface performance sections, with the added benefit of customizable foundations and high-speed response instrumentation to support empirical, mechanistic-empirical, and stochastic pavement design methodologies.

For example, monitoring response instrumentation (i.e., pressure plates and strain gauges) installed in each structural section during construction and documenting changing surface conditions (cracking, rutting, roughness, etc.) under heavy truck traffic facilitates the evaluation of both surface and structural performance. This information provides for the optimization of specifications regarding the implementation of innovative technologies for the pavement infrastructure with a high level of confidence.

The PG15 experiment is designed to deliver two distinct and significant implementable findings to state DOTs. One product will be the quantified relationship between pretreatment pavement condition and the time/traffic needed to return to pretreatment condition for each preservation treatment. This approach avoids any bias resulting from directly comparing the performance of treatments on underlying pavement surfaces of varying condition. State DOTs can implement the life extending benefit curves directly into decision trees to objectively select the most cost effective treatments on their own networks solely as a function of measured pretreatment condition. Pavement management data from states can then be used to calibrate these curves for local climate, materials, contractors, etc. New preservation treatment sections on a high ADT state route will expand the research scope to include different types of recycled pavements and to accurately quantify the condition improving benefit curve of each treatment/treatment combination. This second product will be a valuable tool for program managers who sometimes struggle to prioritize investments in proactive preservation measures.

Budget

A detailed listing of project expenditures will be provided when the draft research plan has been finalized.

Comments

This project is expected to be eligible for 100% SP&R funding. Each sponsor participating in the study is asked to contribute funding as a function of the scope of their selected research. The cost to participate varies as follows according to the amount of effort required:

NCAT and MnROAD Partnership

- Participate in the preservation group (PG15) study - $120k / year ($360k / sponsor)
    - The PG15 cost supports an array of sections on the NCAT and at MnROAD
    - Actual cost to participate in the PG15 study could be less if more states participate
    - Funding can be directed by sponsoring state DOT to either MnDOT or NCAT

- Structural performance section – $210k / year ($630k / section)
    - This option also applies to participation in the cracking group (CG) study
    - The CG cost supports sections on the Track and at MnROAD
    - Actual cost of the CG study could be less if more states participate
    - Funding can be directed by sponsoring state DOT to either MnDOT or NCAT

NCAT Pavement Test Track

- Continue traffic on existing mill/inlay section – $80k / year ($240k / section)
- Surface treatment on existing mill/inlay section - $80k / year ($240k / section)
    - Intended to provide access to project for private sector partners
    - Does not include the cost of materials, construction or mitigation
    - Commitment to rapid mitigation of failed experiments is required
- Continue traffic on existing structural section – $100k / year ($300k / section)
- Mill/inlay surface performance section – $150k / year ($450k / section)
- Mill/inlay structural performance section - $180k / year ($540k / section)

Funding requirements are based on reasonable assumptions; however, if project costs increase significantly (e.g., fuel) either a proportionate amount of additional funding or a modified scope of work may be required. All items purchased through the pooled fund for the execution of this study (regardless of whether it can be categorized as “equipment” or “supplies” by research sponsors) will be retained by Auburn University and/or MnROAD. Please visit the project webs at www.pavetrack.com and http://www.dot.state.mn.us/mnroad/ for additional information.

Minnesota Department of Transportation (MnROAD)
National Center for Asphalt Technologies (NCAT)

Partnership to Advance Research and Implementation

MnROAD and NCAT have partnered to advance pavement preservation research. Sharing resources and expertise will improve coordination of experiments and expand evaluation of pavement performance in both northern and southern climates, providing cost-effective solutions that can be implemented nationwide.

National Effort to Validate Pavement Performance

Recognizing that improved pavement performance is an immediate nationwide goal, MnROAD and NCAT are interested in facilitating the validation of promising technologies through accelerated pavement testing. MnROAD and NCAT are full-scale test tracks that use real-world pavement construction, full-scale truck and live interstate traffic, all under actual climate conditions that effect pavement performance. The combination of traffic loading types and the range in climate conditions provide unique opportunities to address pavement performance issues.

Knowledgeable Technical Staff

A closer relationship between NCAT and MnROAD is a logical progression in developing and evaluating new sustainable technologies, pavement systems and construction methods that lead to safer, quieter, lower cost and longer- lasting roads. Both organizations have core staff members with extensive experience in the operation and analysis of full-scale accelerated pavement testing. Furthermore, staff is continually engaged in technical committees and conferences related to pavement testing, analysis and performance, forming relationships with local, national and international pavement engineering experts. This provides access to breakthrough findings and technologies that can be utilized to conduct more effective and efficient research.

Established Test Tracks

Both test tracks monitor pavement performance routinely for rutting, fatigue cracking, roughness, texture, friction, noise, and structural capacity. All test sections have instrumentation to measure dynamic vehicle load and/or environmental response. The data generated from the physical measurements and instrumentation is used for the development of pavement response models and, ultimately, improved mechanistic-empirical design procedures.

NCAT

The National Center for Asphalt Technology was established in 1986 as a partnership between Auburn University and the National Asphalt Pavement Association Research & Education Foundation to provide practical R & D for maintaining America's highway infrastructure.

NCAT has 46 different test sections on its 1.7-mile oval track. Sections are sponsored on three-year cycles by state DOT's, FHWA and industry. Sponsors have specific research objectives for their sections and shared objectives for the whole track.

MnROAD

MnROAD is owned and operated by the Minnesota Department of Transportation in Albertville, Minnesota. Established in 1994, the test track consists of a 3.5 mile Interstate (I-94) roadway and a 2.5-mile closed loop low volume road (LVR) simulating rural roads. The Interstate diverts live traffic for its loadings and the LVR uses a fully loaded 80K 5-axle semi driven five days a week.

MnROAD has 50 different test sections. Research is sponsored by state DOTs, Minnesota Local Road Research Board, FWHA and industry. MnROAD is in its 2nd phase of research and developing its 3rd phase, scheduled for 2016.

Building on Successful Research and Implementation

Both MnROAD and NCAT have both completed projects with a national impact on improved pavement technology and performance. Each project has demonstrated a high rate of return on customer investments.

NCAT	MnROAD
Superpave mix design methodology was refined to improve durability using results from the Pavement Test Track to lower gyration levels, shift to fine-graded blends, and establish best practices for the use of modified binders.	**Low temperature cracking** has been greatly reduced for new roadways using MnROAD findings. Mixture fracture energy (DCT Testing) is being implemented.
Warm Mix Asphalt implementation was accelerated in the 2003 research cycle in some of the oldest and best documented test sections in the United States.	**Warm Mix asphalt** is performing very well at MnROAD and is the standard asphalt specification used in Minnesota.
SMA and OGFC mix use was expanded by redefining aggregate quality specifications to improve availability and by utilizing reclaimed and recycled materials.	**Innovative diamond grind** has been demonstrated to improve ride and reduce noise on concrete pavements and is being used in Minnesota and nationally.
Thin overlays were shown to provide enhanced cracking resistance and excellent rutting performance.	**Stabilized Full Depth reclamation** was shown to be an effective rehabilitation method. Improvements made to materials have been made and MN has increased its usage.
Structural pavement design, using E, M-E, and stochastic methods, were calibrated to modern methods/materials.	**Whitetopping** (concrete over asphalt) has proven to be a valuable rehabilitation option. Training is being prepared for national implementation.
Reclaimed and recycled materials in high binder replacement mixes were proven to have the potential to reduce construction cost and extend pavement life.	**Drainage** has been shown to affect both HMA and PCC pavement deterioration if not properly accounted for.
Life-extending benefit of pavement preservation is being defined for an array of flexible pavement preservation treatments and treatment combinations.	**Timing of preventive maintenance** (PM) studies indicate that aging impacts asphalt mixtures within one year. Key findings to determine when to apply PM techniques.

Pavement Preservation

Pavement preservation techniques are very cost-effective when applied to the right road at the right time, with benefit-cost ratios as high as 10:1. Accelerated testing at MnROAD and NCAT provides unique opportunities to determine the field performance of breakthrough materials and pavement preservation concepts without the risk of failure that local and state agencies are unwilling to accept. Each facility has a history of evaluating the performance of pavement preservation treatments, including chip sealing, micro-surfacing, crack sealing and thin overlays. To address needs in both northern and southern climates, similar test sections are being developed at each facility to address national issues. Recognizing the long-term nature of measuring the impact of some pavement preservation treatments, both MnROAD and NCAT are pursuing off-site test locations on existing roads and highways that can be easily monitored.

Asphalt Pavement Advancements

NCAT and MnROAD have long histories advancing asphalt technologies. Both have been involved in comprehensive laboratory testing and analyses, the development of new asphalt testing methods and field validation of laboratory findings with full-scale accelerated pavement testing. Through this partnership, future asphalt technologies will be developed more efficiently over a wide range of climate and traffic factors.

Become a Partner

MnROAD and NCAT have established histories of producing cost-effective research findings with a national impact. We invite you to consider this partnership when soliciting organizations to conduct your research. Our combined strength will provide the most cost-effective solutions to the national issues that public agencies are facing.

NCAT and MnROAD Partnership to Address National Needs for Research in Pavement Preservation and Asphalt Mixture Performance Testing

2015 Funding Commitment Letter

Based on our understanding of research needs within the _____, an estimate has been prepared by _____ on _____ that describes one possible sponsorship scenario on the 2015 NCAT / MnROAD Partnership. Assuming all options are selected, a multi-year total of $_____ in funding would need to be programmed in order to support the following proposed research:

Section(s)	Description of Research Option
_____	Sponsors Utilizing "**Preservation Group (PG15) Study**" Option $120,000 per sponsor per year for three years (FY 2015 – FY 2017) for a total of **$360,000**
_____	Sections Utilizing "**Structural Performance**" Option (also applies to **Cracking Group (CG) Study**) $210,000 per new section per year for three years (FY 2015 – FY 2017) for a total of **$630,000**
_____	Sections Utilizing "**Surface Performance Traffic Continuation**" Option $80,000 per mill/inlay section per year for three years (FY 2015 – FY 2017) for a total of **$240,000**
_____	Sections Utilizing "**Surface Treatment on Existing Surface Performance Section**" Option $80,000 per surface treatment section per year for three years (FY 2015 – FY 2017) for a total of **$240,000**
_____	Sections Utilizing "**Structural Performance Traffic Continuation**" Option $100,000 per structural section per year for three years (FY 2015 – FY 2017) for a total of **$300,000**
_____	Sections Utilizing "**Mill and Inlay for Surface Performance**" Option $150,000 per new mill/inlay section per year for three years (FY 2015 – FY 2017) for a total of **$450,000**
_____	Sections Utilizing "**Mill and Inlay in Structural Sections**" Option $180,000 per structural section per year for three years (FY 2015 – FY 2017) for a total of **$540,000**

It is understood that these costs are estimates generated for planning and programming purposes. The actual cost of sponsorship at the time contract documents are finalized may be slightly more or less depending on changes in the cost of diesel fuel, construction materials, etc. between now and then. It is further understood that construction will begin in the spring of 2015, meaning the first payments will be needed in FY 2015. The project will end in FY 2018; however, funds must be provided in annual payments within FY 2015, 2016, and 2017. The first annual payment must be paid no later than March of 2015 in order to facilitate construction activities. The second annual payment is due in October of 2015 (the first month of the next fiscal year). The final annual payment is due in October of 2016. Advance payments (e.g., paying for the next fiscal year as a means of annual research appropriations) are possible and encouraged.

The 2015 preservation group (**PG15**) experiment will extend traffic on all 2012 preservation group (PG) sections until all life extending benefit curve data has been collected, or until the end of the research cycle (whichever comes first). This includes sections on the NCAT Pavement Test Track as well as on Lee Road 159. As sections become unserviceable, they will be rehabilitated or rebuilt to support traffic until the end of the research cycle. Additional sections will be built on a nearby high ADT, high load spectra roadway, with the scope of research expanded to include more recycling alternatives. Sections will also be built at or near the MnROAD facility to study preservation treatments in cold climates. The cracking group (**CG**) study will consist of building new structural sections with surface mixes having a range of cracking susceptibilities as a means to identify practical laboratory cracking tests that can predicts performance. Sections will be built at the NCAT Pavement Test Track as well as at the MnROAD facility to study cracking performance in cold climates and in concrete pavement overlays. If sponsors have a preference regarding which facility will be the focus of their funded research effort, it should be indicated at the bottom of this form. If this section is left blank, it will be assumed that there is no preference.

Space can be reserved in the NCAT / MnROAD partnership experiment by returning a signed copy of this Commitment Letter. In consideration of any additions, changes, or deletions noted above, a multi-year total of $_____ in funding will be programmed in order to support planned research.

Signed for the Sponsoring Agency by: _____

Focus Facility:
□ NCAT Pavement Test Track
□ MnROAD

Printed name of authorized agent: _____

Date of commitment execution: _____