2021 Initial Idea Development

2021-2022 NRRA Research and MnROAD Construction Development
(Form - January 22, 2021)

Initial Proposal is for NRRA Executive Team to Approve for further development (keep to two pages)

Short Research Title:	Validation of Loose Mix Aging Procedures for Cracking Resistance Evaluation in Balanced Mix Design
NRRA Team(s):	Flex
Research/Synthesis:	Research
Developed By:	NCAT, UNH, and TTI
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Expected Construction Costs:	None
Expected Research Cost:	Phase I: $100,000; Phase II: approximately $250,000 (with NRRA states providing material sampling and testing support)
Research Years Expected:	Phase I: 12 to 18 months; Phase II: 36 to 42 months
Partnerships:	Research team, NRRA states, and ongoing NRRA projects

Research Outline:

What is the purpose and need along with the basic steps to a successful research effort?

State highway agencies and the asphalt pavement industry have recognized the importance of asphalt aging for evaluating the cracking resistance of asphalt mixtures in balanced mix designs (BMD) as well as performance-based and performance-related specifications. However, research has indicated that the long-term aging procedure specified in AASHTO R30: aging compacted specimens for 5 days at 85°C, is inadequate. Over the last few years, numerous studies have explored loose mix aging as an alternative yet accelerated method of aging laboratory prepared mixtures to simulate the field aging of asphalt pavements. Some of these studies are briefly described as follows:

- North Carolina State University recommended the use of loose mix aging at 95°C as the long-term aging of asphalt mixtures for performance testing and prediction in NCHRP 9-54. The duration of aging required to simulate in-situ aging of asphalt pavements ranges from days to weeks.
- NCAT developed the "critical" aging procedure for aging of surface mixtures to simulate the changes in mix and binder properties to the point in time when top-down cracking begins to appear, which requires loose mix aging for 8 hours at 135°C prior to compaction. The procedure was initially developed based on analysis of aging of surface mixes from projects in WA, MI, and AL.
- TTI established a "mid-term" loose mix aging procedure for conditioning asphalt overlay mixes which often have performed poorly due to reflective cracking. The mid-term conditioning method calls for 20 hours at 100°C prior to compacting cracking test specimens. Note that the loose mix conditioning time and temperature that are same as those of asphalt binder PAV aging used by DOTs and asphalt industry in the last 30 years.
- UNH has applied the loose mix aging at 95°C and 135°C protocols for a range of NH mixtures and run a range of performance tests. An aging model was developed based on mixture properties and has been correlated with field cores taken after 4 years of service. Two ongoing NRRA projects (Recycling Agents field sections and Compatibility Innovation project) are further evaluating these protocols for application in these projects.

Although these aging procedures showed promising results, they were developed based on a limited number of field projects and component materials. Therefore, further work is needed to validate these procedures with a wider range of field projects with various mixture components, pavement ages, and climatic conditions. The NCAT-TTI-UNH research team proposes a two-phase study to accomplish the research objective. Phase I study seeks to extensively leverage the ongoing research efforts in different regions of the U.S. on the development, evaluation, and preliminary validation of candidate loose mix aging protocols. The research team will synthesize the existing binder and mixture test results (Table 1 and other identified data), conduct critical data review and

analysis, identify research gaps, and develop an experimental plan for Phase II. The Phase II study will leverage existing field projects and new construction projects (especially those containing asphalt additives such as recycling agents, recycled plastics, crumb rubber, etc.) on MnROAD and the NCAT Test Track as well as those in NRRA states. It is anticipated that the Phase II experimental plan will include the following tasks:

1. Selection of several existing and new field projects in different climate zones in the U.S. that allow the sampling of field cores at various in-service times, plant mixes, and raw component materials for research evaluation.
2. Laboratory characterization of field cores, plant mixes, and laboratory produced mixes at various aging conditions based on comprehensive mixture performance testing as well as rheological and chemical testing of extracted asphalt binders.
3. Data analysis to determine the correlation between field aging and the candidate loose mix aging procedures.
4. Identification of appropriate parameters to assess aging effects on asphalt binders' performance, considering the complexity introduced by various additives such as recycling agents, recycled plastics, crumb rubber, etc.

Upon completion of Phase II study, the research team will prepare project deliverables to document and disseminate the test results and research findings of this project as well as provide NRRA states with recommendations and guidance for implementation.

Table 1. Existing Research Efforts on Loose Mix Aging Protocols at NCAT, TTI, and UNH

Research Team	# Test Sections (Location)	Pavement Age (as of 02/2021)	Loose Mix Aging Protocols	Material Availability	Existing Mix Data	Existing Binder Data
NCAT	4 (AL)	5.5 years	8h@135°C, 5d@95°C	FC, PM, RM	I-FIT, IDEAL-CT, Cyclic Fatigue	PG, ΔTc, G-R, LAS, FTIR, GPC
TTI	8 (TX)	6 months	20h@100°C	FC, PM, RM	IDEAL-CT	PG, ΔTc, G-R, LAS, FTIR, XRF
UNH	11 (NH)	4 to 8 years	1-12d@95°C, 24h@135°C	FC, PM	E*, Cyclic Fatigue, I-FIT, DCT	PG, ΔTc, G-R, LAS, Tg
	10 (MN)	1.5 years	6h@135°C, One add'l protocol TBD	FC, PM	E*, Cyclic Fatigue, I-FIT, DCT, SSR, IDEAL-CT, TSR, HWTT	PG, ΔTc, G-R, LAS, Tg, SARA, FTIR
	8 (MN, MO, AL, TX)	1 to 4 years	12d@95°C	PM, RM	E*, Cyclic Fatigue, I-FIT, DCT	PG, ΔTc, G-R, LAS, MSCR, SARA, SEC, FTIR, DSC, TGA

Note: FC = field cores, PM = plant mixes, RM = raw materials.

Pavement Test Cell Outline:

What test sections (MnROAD or other roadways) initial ideas?

This study can use existing and new test sections on MnROAD and the NCAT Test Track as well as roads in NRRA states where the research team can obtain raw materials, loose plant mix, and field cores (annually sampled for up to five years); thus, it will significantly leverage existing research projects without needing dedicated test sections.

NRRA Sustainability/Resiliency and or Intelligent Construction:

How will this project focus on these objectives which are the cornerstone of our NRRA Phase-II efforts?

The lack of consensus on mix aging is a problem for BMD implementation. When BMD is implemented, it will enable more innovative and sustainable mix designs to be evaluated and used at lower risk to highway agencies.

Implementation Plan:

How is this going to be used by its members?

Mix aging should be part of the BMD process for mixture approval and perhaps initial production verification. Research deliverables should include a draft AASHTO standard for the recommended loose mix aging procedure(s) and training materials (presentation slides and videos) to facilitate consistent training.