Executive Summary, Research Readiness Level Assessment, and Technology Transfer

Asphalt Binder Laboratory Short-Term Aging – Phase I and Phase II

Research Benefits

In this study, binders treated by WMA and RA technology will be extracted from plant produced mixtures and also the same binder that was used in the plant before mixing with aggregate will be conditioned in the laboratory by varying the aging parameters. Then the chemical, rheological, and mechanical properties of both extracted and laboratory aged binders will be compared to identify any possible discrepancies and similarities. The findings of this research will be used to improve the current AASHTO/ASTM short-term aging protocol [AASHTO T240/ASTM D2872] and address concerns which have been raised regarding the limitations of the short-term aging equipment (i.e., RTFO) and protocol in the simulation of the aging process that occurs during asphalt mixture production using WMA and RA technology. The modified protocol will ultimately improve the Nebraska quality control and assurance (QC/QA) procedure for short-term aging of asphalt binder.

Phase I Objectives

The objective of this study was to statistically investigate the effect of time, temperature, airflow rate, and asphalt binder weight on the chemical and rheological properties of different asphalt binders in the laboratory short-term aging (RTFO) process. Based on the results and findings of statistical analysis, it was attempted to propose an improved RTFO aging protocol, which was applicable on both unmodified and highly modified binders, without affecting the extent of aging compared to the current standard procedure

Phase II Objectives

The objective of this study is to propose a new/improved RTFO aging protocol, which is applicable on binders produced using WMA and RA technology. To meet the objective of this study, first a comprehensive chemical, rheological, and mechanical evaluation will be performed on binders extracted from plant produced WMA/RA mixtures (field short-term aging). From the same plant and project, we will collect binders and age them by varying the short-term aging parameters; time, temperature, airflow, and weight of binder poured in RTFO jar. Any discrepancies and similarities between field aged binders and lab aged binders will be identified. Then we will attempt to propose a new/improved short-term aging protocol in the lab, based on the tests results.

Background

While blending hot asphalt binder and aggregates in the plant, transporting, and laying the asphalt mixture, hardening of the binder can potentially occur due to the loss of volatiles and/or oxidation. This process is known as short-term aging. The PI and Co-PI proposed a research project entitled “Asphalt Binder Laboratory Short-Term Aging” to statistically investigate the effect of time, temperature, airflow rate, and asphalt binder weight on the chemical and rheological properties of different asphalt binders in the laboratory short-term aging (RTFO) process. In addition, it was attempted to find an improved RTFO aging protocol, which was applicable on both unmodified and highly modified binders. In continuation with the previous research project, finding short-term aging parameters (i.e., new/improved protocol) that can properly simulate the aging process that occurs during WMA production is vital since nearly all of the asphalt mixtures in our state are produced using WMA technology. Also, there is a need for better understanding of short-term aging of asphalt binders treated by RAs since NDOT is planning to use these chemical additives in the Nebraska asphalt mixtures in the near future.

Phase I Conclusion

The Rolling Thin Film Oven (RTFO) is widely used to simulate asphalt binder short-term aging. However, there is a general interest to improve the current short-term aging protocol especially for reducing the aging time. Besides, there are some doubts about the capability of RTFO in the simulation of aging of highly polymer modified asphalt binders which is mainly due to improper dispersion of such binders in the bottles during rotating and creeping of highly viscous binder out of the bottles during rotation. This work addresses the effect of time, temperature, airflow rate, and weight of asphalt binder on the laboratory short-term aging of asphalt binders and proposes an alternative protocol that can reduce the aging time and resolve some of the current short-term aging protocol shortcomings. In the first part of this study, two asphalt binders, from different sources, were examined in RTFO at different combinations of the above-mentioned test parameters. The high-end continuous performance grading temperature (estimated by dynamic shear rheometer), and carbonyl index (estimated by Fourier transform infrared spectroscopy) were considered as the two responses for quantification and qualification of laboratory aging. The statistical analysis showed that the first order terms of time, temperature, and weight as well as their interactive terms were statistically significant. However, the effect of airflow rate, within the studied range, was insignificant. Based on the findings of the first part of study, an alternative protocol was proposed for the study of short-term aging in a RTFO. One unmodified and three highly modified binders were aged in a RTFO under the current and proposed aging conditions for comparative purposes. According to the obtained rheological (high- and low-end continuous performance grading temperature and viscosity) properties as well as the chemical characteristics (carbonyl index, saturate-aromatic-resin-asphaltene fractions, and oxygen content), it was shown that the proposed laboratory short-term aging protocol not only can reduce the aging time of the conventional protocol, but also that it is applicable to both neat and polymer-modified modern asphalt binders.

Executive Summary, Research Readiness Level Assessment, and Technology Transfer

Interested in finding out more?

Phase I Final Report Available: HERE

Phase II Final Report Available: HERE

Principal Investigator
Hamzeh Haghshenas (Phase I and II P.I.)
Jamilla Teixeira (Phase II P.I.)
Mohammad Ghashami (Phase II Co P.I.)
University of Nebraska

NDOT Lead TAC Members
Robert Rea, PE, NDOT Asphalt Engineer

Phase II Conclusion

This study examined the effectiveness of laboratory short-term aging processes for warm mix asphalt (WMA) binders using response surface methodology (RSM) with various combinations of aging parameters: time, temperature, airflow, and binder weight. The research aimed to enhance understanding of aging parameter efficacy and propose a modified laboratory short-term aging protocol that accurately simulates plant short-term aging in WMA binders. Additionally, the study explored the potential of thermal simulation techniques to model the heat transfer within asphalt mixtures during the compaction procedure. To achieve these goals, three WMA mixtures produced at 135 ºC were collected from plants, and their asphalt binders were extracted and recovered. Virgin binders from the same projects were also obtained and two of them aged in a rolling thin film oven at different combinations of aging parameters, designed by RSM. High-temperature performance grade and carbonyl index were used as model responses to quantify laboratory aging levels. These parameters were also assessed in the plant extracted binders to establish target values. The statistical analysis revealed significant effects of time, temperature, and weight, as well as their interactions, on key rheological and chemical properties of binders, while the airflow rate effect within the studied range was found to be insignificant. Two distinct modified protocols for laboratory short-term aging of WMA binders produced at 135 and 165 ºC were developed, showing consistency with plant short-term aged binder results. The models were successfully validated using chemical and rheological assessments of a third binder aged with the proposed protocols. Thermal simulation results indicated that the average allowable time window for compaction increased slightly with the use of finer aggregates and thicker asphalt binder films around the aggregates. Using the available critical window of time for effective compaction ensures the compaction procedure is conducted within the optimal temperature range, leading to more durable pavement layers.

Executive Summary, Research Readiness Level Assessment, and Technology Transfer

Phase I NDOT Recommendations Based Off Research Project – 2021

This research investigated the effect of time, temperature, airflow rate, and asphalt binder weight on the chemical and rheological properties of different asphalt binders in the laboratory short-term aging (RTFO) process. In continuation with this research project, more research is suggesting in finding short-term aging parameters (i.e., new/improved protocol) that can properly simulate the aging process that occurs during WMA production is vital since nearly all of the asphalt mixtures in our state are produced using WMA technology. Also, there is a need for better understanding of short-term aging of asphalt binders treated by RAs since NDOT is planning to use these chemical additives in the Nebraska asphalt mixtures in the near future.

- *As provided by Robert Rea, Lead TAC Member*

Phase II NDOT Recommendations Based Off of Research Project – 2025

This research determined that the Rolling Thin-Film Oven (RTFO) test may not properly simulate aging of heavily modified asphalt binders with additives, showing different rheological properties than those aged in the field. The research proposes alternative testing procedures by changing sample size, testing temperature, testing duration, etc. to better reflect the short-term aging behavior experienced in the field. The results of this research may be considered by the Standing Committee on Binders for Flexible Pavement – Transportation Infrastructure Group AKM20 committee for further advancement. This committee is responsible for the rheological properties concerned with those characteristics of binders that influence performance and maintenance of asphalt pavement, as well as changes in those properties over time. Once the use of heavily modified asphalt binders with recycling agents becomes more prevalent, the alternative testing methods proposed by this research have the potential to be incorporated into new test procedures to more accurately simulate the short-term aging of asphalt.

- *As provided by Robert Rea, Lead TAC Member*

Research Readiness Level (RRL) Assessment

RRL 2

Level 2: Applied Research/Proof of Concept

Research validated and demonstrated in a laboratory environment.

This brief summarizes Project:
"Asphalt Binder Laboratory Short-Term Aging"
"Asphalt Binder Laboratory Short-Term Aging – Phase II"
Nebraska Department of Transportation Research Program