Optimal Timing of Preventive Maintenance for Addressing Environmental Aging in HMA Pavements (MnROAD Study)
Pre-Literature Review
Last Updated - April 21, 2008 (BJW)

Study Number: TPF-5(153)
Study Partners: Local Road Research Board (LRRB), MD, MN, OH, TX
Technical Lead: Benjamin Worel (651) 366-5522

Pooled Fund Web Site www.pooledfund.org

Background One of the major tasks in any transportation agency pavement management system is to select the appropriate alternative for rehabilitation and maintenance. There is a need to understand how preventive maintenance improves the performance of the existing pavements, to develop new techniques, and to determine the optimal timing for the application of these treatments. Perhaps the main reason to apply a preventive maintenance treatment to an HMA pavement is to reduce the aging of the asphalt binder and therefore maintain a higher level of pavement performance. Some research has documented the aging of asphalt through traffic loadings. However, the mechanisms that cause environmental aging are not well understood. This research aims to better understand the mechanisms behind aging and therefore apply the right surface treatment at the right time. This research requires a mixture of fundamental analyses based on laboratory experiments and field investigations. The timing of the surface treatment is related to the aging and distresses that develop in asphalt pavements over time. Ideally, a surface treatment should be applied at the proper time to provide a balance between maximum life and minimum cost. The progression of the asphalt pavement surface condition is mostly related to the aging characteristics of the asphalt binder and to the evolution of the mechanical properties of the binder with aging. An ongoing project at the University of Minnesota is investigating some of the issues related to the application of surface treatments, including environmental (climatic) modeling and mixture and binder testing to determine when preventive maintenance activities should be done.

Objectives: The goal of this study is to determine the proper timing of preventive maintenance treatments in order to optimize life cycle costs and pavement performance. Environmental aging of the asphalt binder in the underlying pavement is not well understood, and this project will seek to better understand the aging mechanism and how it can be reduced through pavement preservation. This pooled fund study is strictly to perform the preventive maintenance research on newly built test sections at MnROAD, and its funding will come from Mn/DOT and other participating states. The funding for initial construction of the test sections will be obtained separately from Mn/DOT and other partners.

Scope of Work:
This project is expected to consist of the following activities:

- Work Plan: The work plan for this pooled fund study will be developed by the participating organizations.
- Instrumentation Design: Thermocouples, strain gages, etc.
- Surface Treatment Application: Determine the parameters to include in designing and applying surface treatments to HMA pavements and/or shoulders at MnROAD. Preventive maintenance treatments (i.e., chip seal, fog seal, rejuvenator, flexible slurry, etc.) will be applied to successive sub-sections at various times throughout the pavement life (from immediately behind the paver to successive years). Consideration will be given to the type of binder in the surface treatment (modified vs. neat).
- General Testing & Monitoring: Monitor the pavement performance over this time on each of the sub-sections. Monitoring activities will include distress surveys, ride measurements, friction, and analysis of pavement sensor data.
- Special Testing & Monitoring: Obtain field cores from each sub-section every year to determine material properties, especially related to aging. The pooled fund panel will recommend the proper laboratory tests to

evaluate the pavement (especially binder) performance under certain surface treatments at certain times during the pavement life, from the refinery through various stages of pavement construction and service life. The testing and monitoring activities will compare untreated vs. treated pavements.

- Pooled Fund Travel: Money for each state to travel to discuss the progress of the study.
- Data Analysis & Report: Work done under a research contract will develop interim and final reports that document the findings of this study.

The research proposed in this pooled fund study aims to fill several gaps in current research projects. Few if any studies have examined the pavement performance after placing a preventive maintenance treatment immediately after construction (year 0), but this could be accomplished in this study. Many of the existing studies monitor pavements under live traffic loadings. This study hopes to examine strictly environmental aging by either leaving pavement sections without traffic or by studying shoulders for their performance under various preventive maintenance treatments. MnROAD has the potential to be only the second site in the country that would apply surface treatments to a pavement with known properties at various times to study the effects of the surface treatments on aging. Finally, MnROAD provides a unique opportunity to study pavements with detailed weather information and known traffic applications in a safe and controlled work environment. The ability to divert traffic allows researchers to monitor and sample test sections in a safe manner, and it encourages researchers to push the envelope and try something new without causing a major disruption to the traveling public if it fails prematurely. The results of this study should lead to recommended guidelines on the timing and value of preventive maintenance applications to HMA pavements.

Related studies include:
The related studies that will be taken into consideration before a work plan is finalized.

TPF-5(112): Midwest States Pooled Fund Pavement Preservation Partnership
Spray Applied Polymer Surface Seals
Foundation for Pavement Preservation
Final Report, August 2007
http://www.pavementpreservation.org/fogseals/Docs/Final_Report.pdf
Pavement Preservation Web Site
http://www.pavementpreservation.org/fogseals/
Gayle N. King, Ph.D.
gking@asphaltscience.com
Cooperative Agreement DTFH61-01-X-00004 (Issued by the Federal Highway Administration)

This study was initiated to determine the effectiveness of seals and evaluate the effects and possible mitigation efforts on safety. This project has four main tasks: collecting existing information; placement of several experimental sections within different climates, traffic levels and surface characteristics; evaluation of field and laboratory test methods and data collected from the test sections; and disseminating the lessons learned.

NCHRP 14-14: Guide for Optimal Timing of Pavement Preventive Maintenance Treatment Applications (Applied Pavement Technology, Inc.)
http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_523.pdf

PROJECT OBJECTIVES - The primary objective of this research was to develop a methodology for determining the optimal timing for the application of preventive maintenance treatments to flexible and rigid pavements. The methodology needed to be flexible enough to consider the variety of treatments that are used and the different ways of monitoring their performance. Also, the methodology needed to be useful both to agencies that already have a preventive maintenance program and to those considering the implementation of such a

program. A secondary objective of the research was to create a user-friendly tool to aid in the implementation of this methodology. Applicability of the methodology was tested using data from actual pavement projects. A plan for obtaining the data needed to support the proposed methodology was also developed to guide agencies not currently collecting preventive maintenance-related data.

NCHRP 14-17: Manual for Emulsion-Based Chip Seals for Pavement Preservation

NCHRP 9-36: Improved Procedure for Laboratory Aging of Asphalt Binders in Pavements (Dr. David Anderson)

TPF-5(045): Performance Guidelines for the Selection of Hot-Pour Crack Sealants (Imad Al Qadi)

TRB HPR-PL-1(43)371: Maintenance Cost Effectiveness Study (Larry Scofield/Dr. Nazarian)

SPR-3(073): Micro-Surface Mix Design Procedure (Caltrans)

LRRB 803, 817: Determination of Optimum Time for the Application of Surface Treatments to Asphalt Concrete Pavements Phase I & II (University of Minnesota)

Determination of Optimum Time for the Application of Surface Treatments to Asphalt Concrete Pavements
Minnesota LRRB Investigation 817
TH 56 1999 Binder Aging Study

The objective of this study is to provide a better understanding of how surface treatments seal and protect the existing pavement from further aging and deterioration from cracking (low temperature, fatigue) and to identify the optimum time for the application of these treatments. This requires a reasonable understanding of the very complex aging mechanism in asphalt materials as well as the effect of aging on their fracture resistance. It is expected this limited research will provide preliminary guidelines in terms of type of treatment and timing of the application.
Contact: Chris Cochran, East Metro Surveys, 651-779-5518

MnDOT county road over the past 10 years have had treatments applied to it to determine the effect the preventative treatments have on aging. Report due very soon – Roger - Jim details?

Texas Transportation Institute
Evaluation of Binder Aging and its Influence in Aging of Hot Mix Asphalt Concrete
Texas Transportation Institute
September 2007
PDF File Attached (TXDOT - Claros) **0-6009_1.PDF**

ANALYZE EXISTING FOG SEAL ASPHALTS AND ADDITIVES: LITERATURE REVIEW
Texas Transportation Institute
December 2005
PDF File Attached (TXDOT - Claros) **0-5091-1.PDF**

Fog and rejuvenating seals have the potential to reduce and reverse the aging of asphalt pavements, reduce cracking and raveling, and provide a better, longer-lasting pavement. The purpose of a fog seal is to coat, protect, and/or rejuvenate the existing asphalt pavement. Also, a fog seal can be used to decrease the permeability to water and air. To the extent such permeability reductions occur, a pavement's waterproofing will be improved and aging susceptibility due to binder oxidation will be reduced. Fog seal emulsions must penetrate into the voids in the

pavement in order to seal off the surface. A slow setting emulsion diluted in water turns out to be a suitable fog seal material in this case. An emulsion that is too thick may not properly penetrate into the surface voids and will leave behind an excess amount of asphalt on the surface after the emulsion breaks, causing a slippery surface. Rejuvenating emulsions contain oils that reduce the viscosity of an existing asphalt, thereby reducing the cohesive failure of the asphalt as the flexibility of binder is improved. In addition, rejuvenating oils can penetrate to fill voids in the pavement and minimize further binder oxidation since the rate of asphalt oxidation is highly dependent on the voids in the total mixture (VTM). An effective rejuvenator must penetrate into the pavement surface in order to be absorbed by the aged hardened asphalt, but also to avoid causing a binder-slick surface, especially in wet weather. This report summarizes literature reports on fog seal and rejuvenator practices and research.

ASSESSING THE ABILITY OF FOG SEALS TO SEAL PAVEMENTS, TO REJUVENATE IN SITU BINDER, AND TO RETARD BINDER OXIDATION

Texas Transportation Institute

February 2007 (Report from the literature review above)

http://tti.tamu.edu/documents/0-5091-3.pdf

This work was conducted for the purpose of assessing the effectiveness of fog seal treatments as an aid to highway maintenance managers in making sound decisions for fog seal treatments. Replicate cores of both treated and untreated highway and general aviation pavement sections were analyzed. Whole cores were assessed by water permeability and by susceptibility to permanent deformation. Replicate cores were sawed into one-quarter inch slices which were individually analyzed for total air voids, accessible air voids, binder content, oxidative aging and rheology, and for the presence of fog seal material. The fog seal materials used in this project were emulsions of asphalt materials and coal tar type materials. Results showed that if the fog seal is penetrating into the pavement, it is not doing so to a detectable level, the permeability of the pavement is not significantly reduced, and APA tests did not show any softening of the pavements by the treatments. Additionally, 1) differences between untreated and treated pavement slices generally seem more likely due to original binder variability with depth than to the fog seal treatments, although coal-tar treatments appear to harden the top layer; 2) effects of the fog seal treatments on oxidative aging were not observed; and 3) previous work, that the aging rates of asphalt binders are decreased by very low accessible air voids is supported. In summary, the effects of fog seals on pavement durability appear to be minimal, with respect to binder rejuvenation or sealing. Cosmetic effects or protecting against shelling or raveling remain as possible benefits, although they were not assessed by this project. In response to this work, engineers should reassess the cost-benefit balance of fog seal treatments.

WRI Studies

http://www.arc.unr.edu/Work_Plans/WorkPlans_Year2-Jan08_FHWA_DTFH61-07-H-00009.pdf

Work Element F1c: Aging (page 113)

Oxidative aging changes binder composition. These changes have dramatic effects on binder (viscoelastic, cohesive, and adhesive) and mixture (viscoelastic, fracture, and permanent deformation) properties. Therefore, it is necessary to understand the material and microstructure factors that influence aging and the factors that govern the response of binders and mixtures to aging. The experiments and analyses will focus on characterizing the influence of aging on fundamental material properties that are included in the parameters of the models discussed in Category 3. Ultimately, the results must be able to provide insight to the asphalt microstructural model, the micromechanics model, and the unified continuum fatigue model and activities of this work element of Category 1 will coordinate with those of Category 3.

* Much of the Asphalt Research Consortium (ARC) work relates to moisture susceptibility, fatigue damage, warm mix asphalt, and low temperature cracking