**Statement/Introduction:**

A review of existing literature was performed relative to management of pavements in poor condition. The review focused on the use of thin surface treatments as stop gap measures to improve ride and prolong useful life until a longer lasting, major rehabilitation or reconstruction, and affordable solution can be constructed.

**Literature/References:**

The following are a listing of discovered documents and reports applicable to this study:

Jianhua Yu (2015) “*Development of Holding Strategies for Deteriorated Low Volume Roads and Evaluation of Performance of Iowa Test Sections*” Iowa Department of Transportation and Iowa State University, Ames.

The Iowa Department of Transportation (Iowa DOT) is developing strategies for maintaining lower volume highways that are near the end of their service life with the intent to delay the more expensive approaches of reconstruction or rehabilitation. The study found that a holding strategy can be successfully employed by selecting treatments that use a combination of thin hot mix overlays, surface treatments and in-place recycling.

An additional phase was added to this project placing surface treatments on composite (HMA over PCC) pavements. A final report will be done at the conclusion of the added phase. Lead researchers on the new phase work are Chris Williams and Chuck Jahren at Iowa State University.

National Center for Freight and Infrastructure Research and Education – CFIRE 05-03 (May 2014), *“Cost Effective Means of Managing Pavements in Poor Condition”* University of Wisconsin Madison, College of Engineering Department of Civil and Environmental Engineering. Minnesota Department of Transportation Contract No. 89264.

The primary focus of the report is on identification of construction treatments and/or materials that can be used to extend the service life of pavements in poor condition. Efforts were made to evaluate performance by comparative economic and environmental life-cycle cost analyses. Cost effectiveness looked at agency costs, agency benefits and user costs including safety.

E. Ray Brown, Michael Heitzman, “*Thin HMA Overlays for Pavement Preservation and Low Volume Asphalt Roads”* National Center for Asphalt Technology NCAT at Auburn University. May 2013.

The goal of this report is to provide guidance for reducing maintenance and preservation costs when using asphalt mixtures on low volume roads. The report investigates several ways to reduce the cost of asphalt mixtures without reducing the expected performance. Some of these methods include using thinner overlays with smaller Nominal Maximum Aggregated Size (NMAS) mixes and using Reclaimed Asphalt Pavement (RAP), Reclaimed Asphalt Shingles (RAS), and Warm Mix Asphalt (WMA).

Eddie Y. Chou, D. Hatta, H. Pulugurta (2008) “Effectiveness of Thin Hot Asphalt Overlay on Pavement Ride and Condition Performance.” University of Toledo, Ohio Department of Transportation, and Federal Highway Administration.

Performance data for thin overlays, 2 inches or less in thickness, constructed by the Ohio DOT since 1990 was assessed to determine the cost effectiveness of thin HMA overlays as a maintenance technique. The study looked at identifying the conditions under which a thin overlay is suitable and timing the construction to maximize benefits. The study found that thin overlays are a relatively low cost alternative in preserving and extending the service life of an existing pavement. The study also noted that projects with insufficient thickness and projects performed on very poor pavements tended not to be cost effective. Thin overlays were most cost effective when the existing pavement’s Pavement Condition Rating (PCR) score was between 70 and 90.

* The performance of thin overlays increased with better existing pavements less annual snowfall, and increased thickness.
* The most important criteria for selecting candidate projects are existing distress conditions and pavement type.

NCHRP Study Synthsis 223 (Geoffry) 1996 thin overlays have a service life of 5 to 8 years.

Used a questionnaire survey of 60 transportation agencies augmented with published information to summarize the cost-effectiveness experience of preventive maintenance treatments. The report concluded that one dollar invested in preventive maintenance at the appropriate time in the life of a pavement could save $3 to $4 in future rehabilitation costs. The most cost-effective pavement management strategy is to perform preventive maintenance activities on the better-rated pavements first and then fund the rehabilitation of the poorer-rated pavements. The worst-first funding strategy is the least cost effective.

Labi Samuel, Sinha (2004) “Effectiveness of Highway Pavement Seal Coating Treatments”. ASCE Journal of Transportation Engineering, January/February 2004.

The paper contends that the direction of seal coating effectiveness in relation to the initial pavement condition depends on the measure of effectiveness used: pavements in relatively poor condition were generally associated with higher jumps in improvement but lower reductions in the rates of deterioration. Greater benefits were observed when applied to roads in relatively good condition particularly when considered over an extended period of time. The study used two measures of effectiveness: estimated performance jump, the instantaneous elevation in performance measures upon application, and deterioration rate reduction, the slowing down of deterioration or flattening of the curve. Pavements in poor condition accrue a higher jump in performance but do not sustain the benefit with the same tenacity as a pavement in good condition.

Also found that rate of deterioration was also related to level of traffic where the greater the traffic volume, the greater the rate on deterioration rate.

Watson D. E., Heitzman M., (2014) NCHRP Synthesis 464 *“Thin Asphalt Concrete Overlays; A Synthesis of Highway Practice”*. National Cooperative Highway Research Program.

The objective of this synthesis is to review the current state of the practice and research effort on the use of thin asphalt concrete overlays for pavement maintenance, rehabilitation and preservation. Pavements that are failing cannot be successfully treated with a thin overlay alone, they must be repaired so that a stable foundation is provided before the thin overlay is placed. Agencies surveyed reported service life of thin overlays to be between 7 and 11 years. Where thin overlays, mill and fill, were applied to badly cracked pavements, the overlay is serving a purpose but is not expected to provide a substantial service life.

Wang, Y., and N. Mastin, *“Cost Effectiveness of Flexible Pavement Treatments: Experience and Evidence”* Journal of Performance of Constructed Facilities ASCE Volume 26 Number 4 2012b.

Survey results from 29 State DOT’s identified thin asphalt overlays as the most expensive initial cost preservation treatment and based upon survey results identified thin overlays extended pavement life an average of 5.4 years, chip seals 1.9 years, crack seal 1.7 years, and slurry seal 1.1 years.

Eltahan, A., J. Daleiden, and A. Simpson. Effectiveness of Maintenance Treatments of Flexible Pavements. Transportation Research Record: Journal of the Transportation Research Board, No. 1680. Washington, DC: Transportation Research Board of the National Academies, 1999: 18–25.

Eltahan et al, (1999) studied the effectiveness of maintenance treatments of flexible pavements

based on data from 28 of the 81 SPS-3 projects located in the Southern region, which includes Alabama, Arkansas, Florida, Mississippi, Okalahoma, Tennessee, and Texas. Their study showed that the original condition of a pavement before maintenance treatment has a major impact on the life expectancy of the treatment. For thin overlays, the median life expectancy was 7.5, 7.3, and 2.5 years when the original condition was good, fair, and poor, respectively. The median benefit of the thin overlay, defined as the number of years added to the median life expectancy due to the thin overlay as compared to that of the control sections (i.e., without treatment), was 2, 4.8, and 2.5 years, when the original condition was good, fair, and poor, respectively. They concluded that applying maintenance to sections with a poor condition, increases the risk of failure by 2 to 4 times. They also found chip seal to outperform thin overlay, slurry seal, and crack seal in controlling the reappearance of distresses.

One year later, Eltahan et al. (1999) conducted survival analysis to evaluate the life expectancy and the effect of the original pavement condition. The authors estimated the failure probabilities of each treatment with respect to the original condition of the test sections using the Kaplan-Meier method. The study concluded that applying treatment to sections in poor condition increased the risk of failure by two to four times, and that CH outperformed the other four treatments.

David E. Newcomb “*Thin Asphalt Overlays for Pavement Preservation”* National Asphalt Pavement Association NAPA. 2009 Information Series 135.

The report investigates thin asphalt overlays approach to pavement preservation. This report provides guidance on when to choose thin overlays, how to select materials and design the mixes, construction and quality control, and what type of performance benefits to expect.

Asphalt Recycling and Reclamation Association – ARRA (2015) “*Basic Asphalt Recycling Manual (BARM)*”, Federal Highway Administration, Publication FHWA-SA-98-042.

The last 25 years have seen a dramatic increase in asphalt recycling and reclaiming existing HMA pavements. The primary focus of the manual is on in-place and cold recycling of HMA pavements providing information on asphalt recycling methods, procedures for evaluation of potential projects, current mix design philosophies, equipment requirements, Quality Control and Assurance, specifications, and performance.

According to the survey responses contained in the Synthesis, for the State of Ohio, the typical pavement age at the time of first thin overlay (years) was 9-10 years, and the typical life span of a thin overlay was 9-10 years. The cost per lane mile was $25,000-$49,999, and the observed increase in pavement life was 7-8 years.

Larry Tschida, Tom Struve, Ed Johnson, “*Installation and Early Field Performance of Mastic Patches on City Streets*” Minnesota OPERA Program, City of Bloomington, MN, City of Minnetonka, MN September 29, 2011.

This study compared the performance of several mastic products versus bituminous patching. In the spring of 2011, the cities of Bloomington and Minnetonka, Minnesota collaborated on a field investigation of the installation and field performance, of two “mastic” patching materials along with standard patches that were applied at the same time. It was found that the labor force for mastic installation was similar to that of asphalt patching, but the mastic requires extra cure time to ensure no-track conditions exist. Mastic products were very successful in restoring ride to deteriorated transverse cracks and potholes on a short-term basis. It was seen that the ride benefits of mastic may improve with time when installed in transvers cracks. Patches did not lose mastic material over a four-month period, but cover rock was lost and should be considered temporary. Mastic materials exhibit a water-proofing advantage over conventional asphalt mixtures.

G. Arnold, G. Mudgway, O. Dickin "*Pavement Maintenance Patch Trials*" New Zealand Transport Agency Research report 635, Dec. 2017.

This report researched a frame work for predicting the life of patches to enable asset managers to choose the right treatment to give the life required with the lowest whole-of-life costs. A total of 12 maintenance patches were constructed consisting of cement stabilization (two cement contents 1.5% and 3%); mill and asphaltic concrete inlay; and full depth granular reconstruction replicated on three different state highways. These maintenance patches were treated as full pavement renewals in terms of testing and investigation prior to their construction. This information allowed basic pavement characteristics, such as the impact of traffic; pavement depth (adequate, inadequate or very inadequate); aggregate quality (good, average or poor); and pavement deflection (high, medium or low), to be determined prior to patching. The patches were monitored for three years and during this period most failed. The monitoring allowed the creation of algorithms based on the basic pavement characteristics to predict the life of the patch treatments. A tool was developed to allow designers and asset managers to make informed choices on the type of patch treatments based on predicted life, and so prevent early failure of the patches.

W. James Wilde, Luke Thompson, Thomas J. Wood “*Cost-Effective Pavement Preservation Solutions for the Real World”* Minnesota Department of Transportation. Report 2014-33. Sept 2014.

This report summarizes pavement preservation activities and recommended uses, expected longevity, and expected pavement life extension. It also includes some basic information intended to be used by those less familiar with pavement preservation, pavement management, life cycle cost analysis, cost estimating, contracting methods and others to help inform and educate in this important aspect of pavement engineering. Tools and techniques are presented to assist local agency engineers in evaluating cost, benefits, timing, longevity, and the decision-making process for developing and effective pavement preservation program on an individual pavement segment to or over an entire network. The most common preservation techniques include routine maintenance and minor rehabilitation that are non-structural. Treatments such as crack sealing, seal coats, thin overlays, micro surfacing, are all examples of common preservation techniques used by local agencies. The report includes examples using real pavement engineering data from several cities and counties in Minnesota to demonstrate topics such as activity timing and the benefits of preventive maintenance plan rather than a reactive one. A set of guidelines was developed as part of the associated project intended to serve as reference material and as a training program.

Harold L. Von Quintus, Amy L. Simpson, Ahmed A. Eltahan “*Rehabilitation of Asphalt Concrete Pavements: Initial Evaluation of The SPS-5 Experiment – Final Report”* U.S. Department of Transportation Federal Highway Administration. July 2006.

The objective of this experiment is to determine the relative influence and long-term effectiveness of different rehabilitation techniques (including overlay thickness, material, and surface preparation) and site conditions (traffic, pre-existing pavement condition, and climatic factors) on performance. This report documents the first comprehensive review and evaluation of data completeness and availability from the SPS-5 experiment.