pennsylvania
DEPARTMENT OF TRANSPORTATION

Evaluation of Thin Hot Mix Asphalt Overlay

FIELD EVALUATION SUMMARY REPORT

June 20, 2016

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COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION

CONTRACT # 355I01
PROJECT # 110807

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Evaluation of Thin Hot Mix Asphalt Overlay: Field Evaluation Summary Report		**5. Report Date** June 20, 2016 **6. Performing Organization Code**
7. Author(s) Mansour Solaimanian and Shelley Stoffels		**8. Performing Organization Report No.** LTI 2017-01
9. Performing Organization Name and Address The Thomas D. Larson Pennsylvania Transportation Institute The Pennsylvania State University 201 Transportation Research Building University Park, PA 16802-4710		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** 355I01 - 110807
12. Sponsoring Agency Name and Address The Pennsylvania Department of Transportation Bureau of Planning and Research Commonwealth Keystone Building 400 North Street, 6th Floor Harrisburg, PA 17120-0064		**13. Type of Report and Period Covered** Final Report: 6/21/12 – 6/20/16 **14. Sponsoring Agency Code**

15. Supplementary Notes

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16. Abstract

Preserving the road surface and maintaining it at a proper functional level is essential to safe transportation. Among alternatives for pavement surface treatment, thin asphalt overlays have been utilized and promoted by several states to serve this need. To evaluate the performance of such overlays and develop relevant specifications, PennDOT initiated a four-year research program with Penn State. The project carried several major objectives. One was to assess best practices for design and construction of such mixes through field application of three pilot projects and conducting necessary laboratory testing. Second was to evaluate the performance of such mixes placed in these pilot projects through visual survey and pavement condition measurements. Third was the use of existing advanced technology such as thermal imaging and ground-penetrating radar to determine the uniformity of such mixes during placement in regard to temperature and density. Finally, it was the intention of the project to develop relevant specifications and guidelines for thin asphalt overlays. Field evaluations, in general, indicated satisfactory performance of these roads. This report does not cover the research team's field work during construction. The construction-related work, including thermal imaging and ground penetrating radar measurements, is covered in separate reports. This summary report presents a brief presentation of results from pavement condition evaluation conducted at several intervals during the time this research was conducted.

17. Key Words	18. Distribution Statement
Thin asphalt, pavement, distress, rutting, cracking, GPR, thermal imaging	No restrictions. This document is available from the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	10	N/A

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

This work was sponsored by the Pennsylvania Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration. The contents of this report reflect the views of the author, who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of either the Federal Highway Administration, U.S. Department of Transportation, or the Commonwealth of Pennsylvania at the time of publication. This report does not constitute a standard, specification, or regulation.

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INTRODUCTION

There is widespread recognition that highways are among the most valuable assets of the nation. Preserving this asset in a quality way, and maintaining it at a proper functional level, is essential to the overall health of the communities. Deterioration of our highway system will endanger public safety and will adversely impact the economy and people's daily commutes. At the same time, the need to stretch allocated transportation budgets puts the burden on state highway agencies to seek the best economical ways of addressing the need of pavement preservation. Among alternatives for pavement surface treatment, thin asphalt overlays have been utilized and promoted by several states to serve this need.

The Pennsylvania Department of Transportation (PennDOT) has been using various pavement treatment and preservation techniques for decades. Recently, PennDOT, in collaboration with industry, has been looking into thin asphalt overlays and their best applications on Pennsylvania roads. To evaluate the performance of such mixes and develop relevant specifications, PennDOT initiated a four-year research program with Penn State, titled "Evaluation of Thin Hot Mix Asphalt Overlay." The project began in June 2011 and was completed in June 2016. The project carried several major objectives. One was to assess best practices for design and construction of such mixes through field application of three pilot projects and conducting necessary laboratory testing. Second was to evaluate the performance of such mixes placed in these pilot projects through visual survey and pavement condition measurements. Third was the use of existing advanced technology such as thermal imaging and ground penetrating radar to determine uniformity of such mixes during placement in regard to temperature and density. Finally, it was the intention of the project to develop relevant specifications and guidelines for thin asphalt overlays.

The first pilot project included application of thin hot mix asphalt overlay at SR 0022 (Cameron Road) in Dauphin County. The mix was placed on repaired jointed concrete in July 2012. It was during June 2013 when the second hot mix asphalt was placed on SR 0230 in Lancaster County, again on repaired jointed concrete. The last project included placement of thin asphalt on SR 0220 in Lycoming County in September 2013. For this project, warm-mix asphalt, processed through foaming, was placed on the milled road, and on the top of an old asphalt concrete, lying over jointed concrete.

Laboratory testing included evaluation of rutting and fatigue cracking of the mixes through wheel tracking and overlay tester, respectively. Resistance to rutting from lab testing proved to be excellent for the SR 0022 and SR 0230 projects. For SR 0220, there were two sections of the road, with one of the two including fiber in the mix. The fiber section had lower rutting compared to that of the no-fiber section. However, neither one has demonstrated any rutting problems in the field. The overlay test for all three projects showed that the mixes passed cracking criteria.

OBJECTIVES OF THE STUDY

This research project was focused on polymer-modified thin hot-mix asphalt overlay (THMAO) constructed with 6.3-mm nominal maximum aggregate size. The objective of the research was to determine the feasibility of constructing this type of THMAO and to evaluate the performance of this mix in both the laboratory and the field. It was also the research goal to modify existing specifications or develop new specifications and guidelines for the use of this material, in cooperation with PennDOT and industry. In addition to such modifications to existing specifications, a best practices document covering design and construction of such mixes was to be developed based on findings from construction of demonstration projects.

SCOPE OF FIELD EVALUATION

- Documentation of construction and relevant findings (3 reports)
- Thermal imaging of selected sections of the road to evaluate mat temperature variability (provided with construction reports)
- Use of ground penetrating radar to determine mat uniformity with respect to density, and mat thickness (included in the construction reports)
- Coring to determine tack coat bond strength, layer thickness, and mat density
- Pavement condition survey (18 reports)
- Rut profiling (provided in the pavement condition survey reports)
- Visual distress survey, crack measurement, and rut measurement (provided in pavement condition survey reports)
- Friction evaluation using dynamic friction tester (twice during the project and provided in the pavement condition survey reports)
- Texture evaluation using circular track meter (twice during the project and provided in the pavement condition survey reports)
- Skid measurements (conducted by the PennDOT Bureau of Maintenance and Operations (BOMO) and provided in the pavement condition survey reports)
- Pavement rutting, ride quality, cracking, and distress survey (conducted by BOMO and provided in the pavement condition survey reports)

This report does not cover the research team's field work during construction. The construction-related work, including thermal imaging and ground penetrating radar measurements, is covered in three separate reports, each titled *Findings from THMAO Application and Paving*. This summary report presents a brief presentation of results from pavement condition evaluation conducted at several intervals during the time this research was conducted.

PAVEMENT CONDITION EVALUATION

Detailed results of pavement condition evaluation were provided to PennDOT in eighteen reports. The number of field evaluation reports submitted to PennDOT for SR 0022, SR 0230, and SR 0220 were, respectively, seven, six, and five. Pavement condition assessment was conducted by both the research team and the PennDOT BOMO. Assessment by the research team included the following:

- Visual survey
- Crack measurement
- Rut measurement (twice during the project)
- Friction measurement (twice during the project)
- Texture measurement (twice during the project)

Measurements by BOMO included the following

- Ride quality (international roughness index, IRI)
- Rutting
- Friction (Skid)
- Videologging

Table 1 presents dates of site visits by the research team as well as dates of BOMO measurements.

Table 1 Dates of Distress Survey and Pavement Condition Assessment of the Thin Overlay Projects.

Project	Dates of Penn State Survey	Dates of Skid Measurements by BOMO	Dates of Pavement Condition Measurements by BOMO
SR 0022, Dauphin	11/08/12, 11/19/13, 04/24/14, 10/23/14, 05/20/15, 11/04/15, 04/18/16	03/29/12, 08/28/12, 06/3/14, 10/06/14, 04/24/15, 10/23/15, 04/20/16	04/04/12, 07/31/12, 09/12/12, 11/05/13, 06/03/14, 09/18/14, 04/06/15, 10/14/15
SR 0230, Lancaster	11/19/13, 04/04/14, 10/17/14, 04/23/2015, 11/03/15, 04/19/16	06/03/13, 08/19/13, 06/03/14, 10/06/14, 04/30/15, 10/01/15, 04/11/16	05/20/13, 07/11/13, 06/3/14, 09/19/14, 04/28/15, 10/14/15
SR 0220, Lycoming	04/10/14, 10/08/14, 04/28/15, 10/27/15, 04/20/16	07/1/13, 11/18/13, 05/27/14, 09/16/14, 04/13/15, 10/6/15, 04/13/16	06/24/13, 11/21/13, 06/2/14, 09/24/14, 07/27/15, 10/22/15

Rutting Assessment

BOMO videologging profile summaries and rut profile measurements by the research team indicate significant reduction in rutting for all three projects as a result of thin asphalt placement. There has been gradual increase in the level of rutting with time after placement, but the rut depth remains very low in most cases. Including all sites, for the left wheel path, the range for rutting is 0.08 to 0.16 inches and for the right wheel path, 0.07 to 0.12 inches, based on measurements of the research team. BOMO results indicate an average range of 0.07 to 0.14 inches for the left wheel path and a range of 0.06 to 0.11 inches for the right wheel path, for all projects combined. All reported numbers are based on measurements from October 2015.

Cracking/raveling Assessment

There is little evidence of considerable raveling at these sites. The severity of raveling has been low to moderate. Of the three projects, SR 0220 presents the lowest level of raveling. Similarly, fatigue-related cracking has been low for SR 0022 and SR 0230, and almost non-existent for SR 0220. Since the first evaluation to date, it has been found that reflective cracking is the only dominant type of distress in all three roads. These are reflection of cracks from the concrete joints or underlying cracks. For SR 0022, the limited fatigue cracking has been the result of propagation of reflective cracks at the transverse joints. For SR 0230, the limited fatigue cracking has been the result of propagation of reflective cracks at the longitudinal joint between the concrete pavement and asphalt shoulder. The first set of cracks started appearing just a few months after placement. In SR 0022 and SR 0230, the cracks increased in number and became wider with time. For these two projects after placement of thin asphalt, the pavement was sawed and sealed at the joint locations, but in cases where this was not done or in cases where the seal was misplaced or conducted improperly, the cracks appeared. Some of these cracks have deteriorated and widened with time. In both roads, the developed cracks were sealed at a later time. For SR 0022, hot-pour crack seal was applied and for SR 0230 spray seal was used. In both cases, some cracks were missed at the time of sealing. The injection spray seal at SR 0230 was performed poorly and some of the sealing material is now missing from the wide cracks it was used to fill.

Friction Assessment

For each pilot project, skid tests were conducted by PennDOT BOMO seven times during the life of this research. Furthermore, friction measurements were conducted by the research team twice during the course of the project. Penn State measurements were achieved using a dynamic friction tester. Friction values for all three projects from Penn State measurements ranged between 0.60 and 0.62, calculated for a speed of 12 miles per hour. The BOMO skid data indicate significant improvement in skid resistance after placement of thin asphalt overlay for all three projects. For SR 0022, prior to thin asphalt placement, skid numbers were in the range of 20 to 30. After placement of thin overlay, the numbers exceeded 50. For SR 0230, the skid values increased from 30-level to 50-level after placement of thin asphalt overlay. Among the three projects, SR 220 delivered the smallest increase in skid resistance after placement of thin asphalt overlay. On average, the skid numbers changed from an average value of 44 to an average value of 52 after placement. There has been a gradual decrease in friction with time for SR 0220, and the skid resistance numbers have dropped to levels similar to those observed prior to THMAO paving, even though the skid numbers are still at an acceptable level.

Assessment of Ride Quality

Similar to skid resistance, the ride quality significantly improved after placement of the thin asphalt, as evidenced by international roughness index and based on BOMO measurements. The ride quality has slightly deteriorated with time for SR 0022 and SR 0230, but it still remains well above the level prior to thin asphalt placement. For SR 0220, the IRI has maintained almost the same level since placement of the thin asphalt.

Assessment of Surface Texture

The surface texture was measured using the Circular Track Meter (CTM). The charge-coupled device (CCD) laser displacement sensor used by this equipment is mounted on an arm that rotates above the road surface. The measurement results are used to report different surface texture indices. The CTM device can be used to measure the macrotexture of the test surfaces. The measured texture profile is then used to calculate the international standard mean profile depth (MPD) parameter, which is a direct macrotexture parameter. During the last measurement in October 2015, the average MPD was found to be 0.69 mm for SR 0022, 0.64 for SR 0230, and 0.43 for SR 0220. Higher MPD is more desirable, as it tends to deliver better skid resistance. For SR 0220, BOMO skid measurements delivered the lowest values among the three projects, consistent with the lowest MPD values obtained with CTM. Lower MPD for SR 220 could be the result of finer gradation used at this site compared to the other two sites, as well as the fact that the sandstone was contaminated with limestone. In revising specifications for 6.3-mm mixes, consideration was given to aggregate gradations as a result of skid and MPD values obtained during this research.

SUMMARY

Field evaluations, in general, indicated satisfactory performance of these roads. Considerable improvement has been achieved in terms of ride quality and skid resistance after placement of thin asphalt. Roughness numbers, indicating ride quality, remain low and well below the values obtained prior to placement of the thin asphalt overlay. Considerable increase in skid resistance level was noticed after placement of the thin overlay. The exception is SR0220, for which the skid numbers were already high and skid resistance improvements were not as significant as for the other two projects. Within these first few years after placement of thin mixes, there has not been significant change in skid resistance and the values remain high. One area of concern is with the skid resistance at SR 0220, which shows gradual decrease with time, dropping to the prepaving levels. It is our assessment that skid resistance could have been further improved for this site through a coarser aggregate gradation and better control of aggregate skid resistance level.

Field measurements have indicated minimal rutting, fatigue cracking, and raveling at all three sites. Reflective cracking has been the dominant distress at all three projects. All three projects have suffered reflective cracks from underlying concrete joints or cracks. The reflective cracks at SR 0022 and SR 0230 have widened with time, triggering crack sealing operation.

The pilot projects are three and four years old at the time of this writing. Overall, it can be assessed that both construction and performance of the three pilot projects have been successful based on observations within this limited period of time. Various performance measures have been used through the course of research to demonstrate the success of these projects. The results of the study were reflected in newly developed construction specifications for 6.3-mm mixes as well as construction guidelines and a manual of best practices.