TEXAS TRANSPORTATION INSTITUTE
THE TEXAS A&M UNIVERSITY SYSTEM

Project Summary Report 0-4150-S

Project 0-4150: Evaluation of Pavement Marking Effectiveness

Authors: H. Gene Hawkins, Jr., Timothy J. Gates, Elisabeth R. Rose

PROJECT SUMMARY REPORT

Pavement Marking Effectiveness and the Pavement Marking Handbook

Pavement markings provide one of the primary means of communicating information to road users. Unlike traffic signs and signals, pavement markings are continuous and provide road users with valuable information that helps them properly position the vehicle within the travel way. Pavement markings are different from signs in another way: pavement markings are typically manufactured at the location where they are applied instead of being manufactured in a factory and sent to the installation site. As a result, there is the opportunity for greater variability in the performance characteristics of pavement markings.

Pavement markings are a primary means of communicating with road users.

What We Did ...

This project evaluated several key characteristics associated with the retroreflective performance of pavement markings. There were five major activities associated with this project:

- conduct of two conferences on pavement marking performance,
- evaluation of pavement marking retroreflectivity on flexible pavements (hot-mix asphalt and surface treatments),
- identification of pavement marking use on rigid pavements (concrete),
- evaluation of the measurement of marking thickness, and
- development of the *Pavement Marking Handbook.*

Pavement Marking Conferences

During the first year of the project, The Texas Transportation Institute (TTI) hosted two pavement marking conferences to identify and discuss important issues associated with pavement markings in Texas. Key pavement marking stakeholders in Texas, including many Texas Department of Transportation (TxDOT) representatives, attended these conferences. The first conference was an invitation-only meeting held in College Station with a limited number of individuals (35) that was intended to identify what the major pavement marking challenges are.

The second conference was held in Austin and was open to all who wished to attend. The many individuals who attended (139) heard presentations from marking experts with other state transportation agencies, the Federal Highway Administration, and industry. Primary issues that were discussed at the conferences included: thermoplastic application on sealcoat surfaces, striping inspection, performance and warranty pavement marking specifications, and de-bonding of thermoplastic from concrete.

Markings for Flexible Pavements

Providing long-lasting thermoplastic pavement markings on surface treatment (sealcoat) surfaces has become a challenge for some TxDOT districts. The

researchers performed a number of tasks to identify effective pavement marking practices for sealcoat and hot-mix asphalt concrete (HMAC) roadways in Texas. The researchers reviewed literature, identified current TxDOT and alternative pavement marking practices, and evaluated various pavement marking treatments in the field. The pavement marking field evaluations were performed on surface treatment and HMAC roadways. In most of these field evaluations, researchers measured the retroreflectivity of newly applied pavement markings and monitored the performance of the markings over time. In total, researchers made more than 9000 retroreflectivity measurements at 18 different sites. Figure 1 presents a comparison of white edgeline retroreflectivity over time for various marking thicknesses.

Markings for Concrete Pavements

Several TxDOT districts have experienced difficulties getting the standard TxDOT thermoplastic marking material to provide adequate durability on concrete pavements. In some districts, thermoplastic markings have an expected life span of a year or less due to de-bonding between the marking and pavement surface. To address these items, the researchers synthesized information from a number of sources, including National Transportation Product Evaluation Program (NTPEP) data and other state transportation agencies. This information was used to develop recommendations for the selection of marking materials on concrete pavements.

Measuring Pavement Marking Thickness

Pavement marking thickness is one of the two primary inspection measurements made with pavement markings, the other being retroreflectivity. Researchers compared the relative accuracies of thermoplastic thickness measurement with caliper (common field practice) versus needlepoint micrometer (recommended field practice). The main difference between the two measurement devices is that the needlepoint micrometer is capable of measurement between the beads, while the caliper is capable of measuring only to the top-of-bead. The difference between the two devices is significant because TxDOT specifications require contractors to achieve minimum thermoplastic binder thickness, not including drop-on beads.

Pavement Marking Handbook

Developing the TxDOT *Pavement Marking Handbook* was the major implementation effort of the project. Using the information gained from the other four activities, TTI researchers developed the handbook and refined the content based on input from a panel of TxDOT staff and selected contractors that met on several occasions to contribute to the development of the handbook. The handbook was developed to provide a single source of information for anyone involved with pavement markings in Texas.

What We Found ...

The researchers identified numerous findings that can have an impact on the quality of pavement markings and the resulting effectiveness of those markings.

Pavement Marking Conferences

The findings from these conferences provided the researchers and TxDOT staff with much useful information. Research report 0-4150-3, *A Summary of Two Pavement Marking Conferences for the Texas Department of Transportation*, summarizes the activities and findings from the conferences. Significant suggestions resulting from the conferences include:

- Use 100 mil thermoplastic for all longlines on new sealcoat.
- Experiment with concrete-specific thermoplastic materials and two-component materials (e.g., epoxy) on concrete pavements.
- Establish consistent statewide striping inspection practices.
- Establish a single statewide retroreflectivity performance specification.

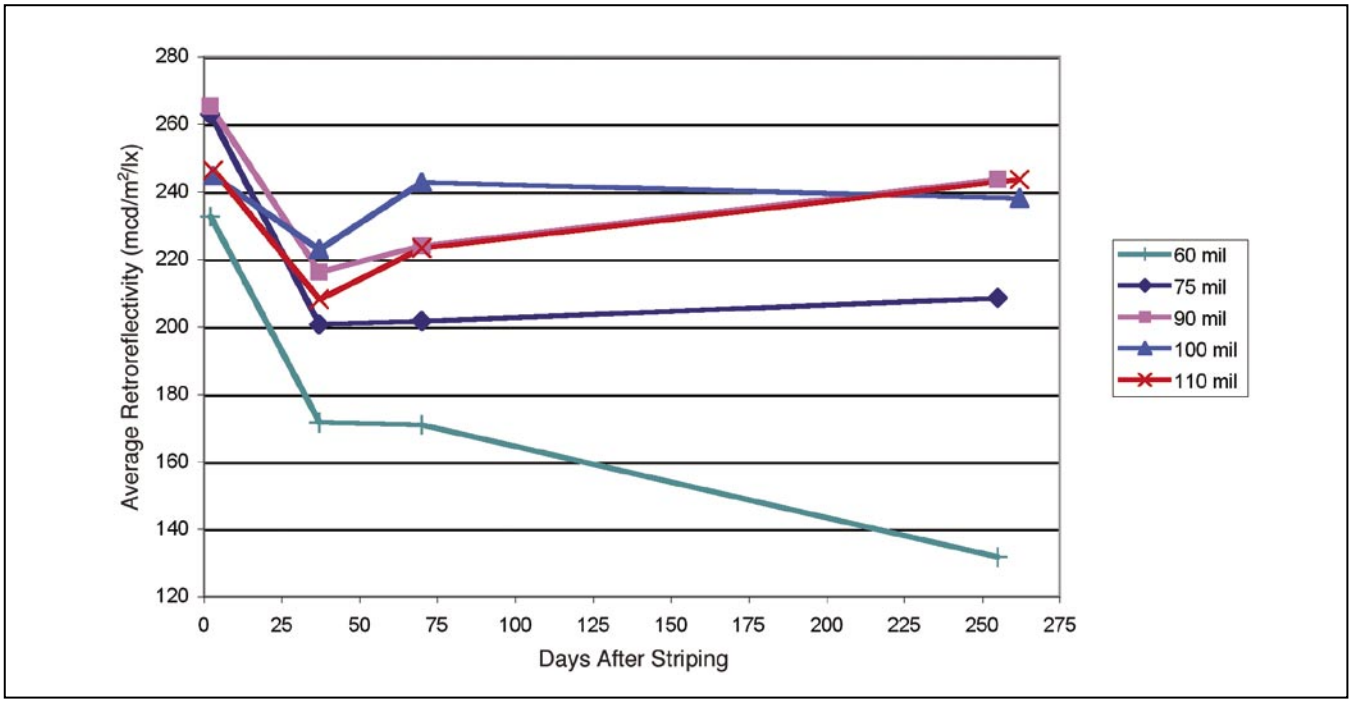

Figure 1. Average Retroreflectivity for White Edgeline.

- Warranty specifications should be limited to use only on selected contracts at the local level.
- Monitor marking retroreflectivity on a number of different roadway types to determine reasonable retroreflectivity values and performance periods.
- Until more experience is obtained, use 250 mcd/m^2/lux white and 175 mcd/m^2/lux yellow for minimum retroreflectivity performance of new markings.

Markings for Flexible Pavements

The researchers identified few shortcomings related to pavement marking practices on HMAC pavement surfaces. However, for surface treatments, numerous opportunities for improving pavement marking quality were identified. Research report 0-4150-4, *Effective Pavement Marking Practices for Sealcoat and Hot-Mix Asphalt Pavements*, summarizes the results of the evaluations. Based on the research findings, numerous recommendations were developed, which include:

- Apply thermoplastic at a minimum thickness of 100 mil for all longitudinal pavement markings on new surface treatments when no other durable marking exists.
- Apply thermoplastic at a maximum thickness of 90 mil for all longitudinal pavement markings on HMAC when no other durable marking exists.
- Water-based paint may be used on a new surface treatments in either of the following situations, but should not be used as a permanent marking:
  - as temporary pavement marking for up to 6 months, or
  - as surface primer prior to thermoplastic application.
- For better retroreflective performance of pavement markings on surface treatments, TxDOT Grade 4 sealcoat aggregate (smaller diameter) is recommended over TxDOT Grade 3 sealcoat aggregate (larger diameter).
- For any pavement surface, use either TxDOT Type III (larger diameter) or TxDOT Type II (smaller diameter) glass surface beads with thermoplastic to achieve suitable levels of dry-weather retroreflective performance.

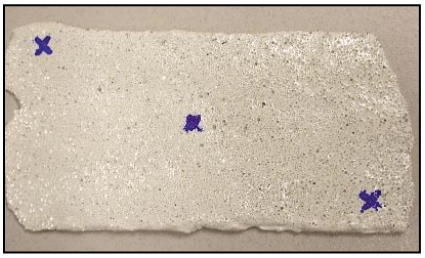

Figure 2. Locations for Measuring Marking Thickness.

- To obtain a more accurate representation of long-term pavement marking performance, measure retroreflectivity at least one month after striping.
- To ensure adequate retroreflectivity for both directions of traffic, measure retroreflectivity for centerlines of undivided two-way roadways in both directions.

Markings for Concrete Pavements

The researchers gathered much useful information regarding pavement marking practices for concrete pavements. Research report 4150-2, *Effective Pavement Marking Materials and Applications for Portland Cement Concrete Roadways*, summarizes the findings and recommendations associated with this effort. Based on findings, the researchers generated a number of recommendations for pavement markings on concrete roadways in Texas, which include:

- Use epoxy materials for long-term applications under the majority of traffic conditions.
- Use preformed tape for long-term applications under very heavy traffic.
- Use TxDOT specification thermoplastic only for short-term applications with low to medium traffic.
- Always ensure that the striping surface is clean and dry with no loose material.
- Special concrete thermoplastic formulations (not currently included in TxDOT specifications) are suggested for all other thermoplastic applications on concrete.

Measuring Pavement Marking Thickness

Forty-seven thermoplastic pavement marking samples of varying thickness and beads were taken from striping jobsites statewide and used in the analysis. Research report 4150-1, *Analysis of TxDOT Thickness Measurement Procedures for Thermoplastic Pavement Markings*, summarizes the findings from the analysis. The results show that the caliper measured an average of 20.5 mil and 16.7 mil thicker than the needlepoint micrometer for large (Type III) and small (Type II) bead samples, respectively. Based on the research findings, the following recommendations were made:

- Thickness measurements should be made with a needlenose micrometer to the top of the thermoplastic.
- The use of a caliper to measure thermoplastic thickness is discouraged.
- A minimum of three measurements should be taken.
- The most accurate measurement method is to measure diagonally across the sample (taking at least three measurements per sample). Figure 2 illustrates where the measurements should be made on the sample.

The Researchers Recommend ...

The *Pavement Marking Handbook* serves as the implementation product for the various research activities associated with this project. It contains guidance, procedures, and recommendations addressing many different aspects of pavement marking selection and installation. The objectives of the *Pavement Marking Handbook* are to:

- harmonize statewide practices,
- implement research, and
- provide a single "go-to" resource for striping.

The handbook is divided into two main chapters: pavement marking material selection and pavement marking installation and inspection. Each chapter serves as a stand-alone document. The handbook provides TxDOT engineers and inspectors with information that will help them better select pavement marking materials and inspect the installation of markings.

For More Details . . .

The research is documented in four research reports:

- 4150-1: *Analysis of TxDOT Thickness Measurement Procedures for Thermoplastic Pavement Markings*
- 4150-2: *Effective Pavement Marking Materials and Applications for Portland Cement Concrete Roadways*
- 0-4150-3: *A Summary of Two Pavement Marking Conferences for the Texas Department of Transportation*
- 0-4150-4: *Effective Pavement Marking Practices for Sealcoat and Hot-Mix Asphalt Pavements*

Research Supervisor: H. Gene Hawkins, Texas Transportation Institute, gene-h@tamu.edu, (979) 845-6004

Researchers: Timothy J. Gates, and Elisabeth R. Rose, Texas Transportation Institute

TxDOT Project Director: Greg Brinkmeyer, TxDOT–Traffic Operations Division, gbrinkme@dot.state.tx.us, (512) 416-3120

To obtain copies of reports, contact Dolores Hott, Texas Transportation Institute, TTI Communications, (979) 845-4853, or e-mail d-hott@tamu.edu. See our online catalog at http://tti.tamu.edu.

The *Pavement Marking Handbook* (4150-P1) is the implementation product for this research. It is available from the TxDOT Traffic Operations Division. Contact Jeanne Black at (512) 416-3134 to order a copy of the handbook.

TxDOT Implementation Status
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The objective of this research project was to evaluate key aspects of pavement marking effectiveness. One product was required for this project: a pavement marking handbook. The *Pavement Marking Handbook* can be implemented immediately as it was developed as the single source of information for anyone involved with pavement markings in Texas.

For more information, contact Mr. Wade Odell, P.E., RTI Research Engineer, at (512) 302-2363 or email wodell@dot.state.tx.us.

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