Evaluation of Durable Crosswalk and Stopbar Marking Materials

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EVALUATION OF DURABLE CROSSWALK
AND STOPBAR MARKING MATERIALS

by

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May 1986
The objective of this study was to find the most cost-effective durable marking material to provide long-lasting stopbars and crossbars. Three materials were tested: 1) 3M Stamark tape, 2) Prismo preformed tape, and 3) extruded thermoplastic (hydrocarbon and alkyd). The various test installations were in place for between 6 and 30 months.

The alkyd-resin thermoplastic material was found to be the most cost-effective material. The preformed tapes cost two to three times as much as the thermoplastic material while not providing as durable a material when used in this application. The alkyd-resin material maintained its appearance better than the hydrocarbon-resin material.

Use of alkyd-resin extruded thermoplastic material was recommended either by contract or with Kentucky Transportation Cabinet personnel if the necessary equipment was obtained. The exceptions where preformed tape shall be used were 1) at isolated intersections where use of thermoplastic installation equipment was impractical and 2) on concrete pavements.
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Kentucky Transportation Research Program
University of Kentucky
Lexington, Kentucky

in cooperation with
Transportation Cabinet
Commonwealth of Kentucky

and

Federal Highway Administration
US Department of Transportation

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EXECUTIVE SUMMARY

Because of the durability problem experienced with existing materials, test projects using more durable materials for marking crosswalks and stopbars were installed and evaluated. Materials included in the tests were two different preformed tapes (manufactured by 3M (Stamark tape) and by Prismo) and hot-extruded thermoplastic material (using both a hydrocarbon resin and an alkyd resin). The objective of this study was to find the most cost-effective marking material to provide long-lasting stopbars and crosswalks.

Data were collected to evaluate durability, reflectivity, and appearance. The evaluation period was about 30 months for the two preformed tapes and the hydrocarbon-resin thermoplastic material. Two alkyd-resin thermoplastic projects were installed with evaluation periods of 17 months and 6 months.

Costs of the two preformed tapes were similar but were two to three times the cost of the thermoplastic material. The cost of the alkyd-resin thermoplastic material was slightly higher than that of the hydrocarbon-resin material.

Both preformed tapes experienced initial durability problems. The Stamark tape had problems in areas of high-volume turning movements as well as in the area between wheel paths. The Prismo tape had problems of maintaining a proper bond with the pavement and delamination of the tape layer from the adhesive.

The thermoplastic material did not experience these durability problems although a significant wear in the wheel paths was noted after a period of time.

All the materials sustained a significant loss in reflectivity. The highest reflectivity measurements were observed for the alkyd-resin thermoplastic material, but reflectivity of this material decreased substantially from initial readings.

Both preformed tapes maintained their appearance fairly well as did the alkyd-resin thermoplastic material. The hydrocarbon-resin thermoplastic material sustained some discoloration between the wheel paths, especially in turning lanes, due to oil staining.

The conclusion of the evaluation was that the alkyd-resin extruded thermoplastic material was the most cost-effective material for crosswalk and stopbar installations.
INTRODUCTION

Painted crosswalks and stopbars at high-volume intersections are subjected to excessive wear. When typical paints are used, they must be restriped frequently or remain in an undesirable condition.

Because of the durability problem experienced with existing materials, test projects using more durable materials were installed as part of the Pavement Marking Demonstration Program. Materials included in the tests were two different preformed tapes and hot-extruded thermoplastic material (hydrocarbon resin). During the test period, two projects, using an alkyd rather than hydrocarbon resin in the thermoplastic material, were completed in Fayette County. These projects were included in the tests.

The objective of this study was to identify the most cost-effective marking material to provide long-lasting stopbars and crossbars. The original test installations have been in place for about 30 months. The two alkyd-resin thermoplastic projects have been in place for 17 months and 6 months.

INSTALLATIONS

Three separate contracts were awarded initially for installation of experimental marking materials. A summary of costs and quantities of the various installation contracts is presented in Table 1. The installations consisted of 6-inch crosswalks and 24-inch stopbars. Bid prices were in terms of cost per linear foot. The preformed tape contracts and the first hydrocarbon-resin thermoplastic contract were installed as part of the Pavement Marking Demonstration Program. The two alkyd-resin and the second hydrocarbon-resin thermoplastic contracts were installed by the Lexington-Fayette Urban County Government.

The contract in Boone, Campbell, and Kenton Counties (Northern Kentucky) specified a preformed plastic material (tape) that had a thickness of 90 mils. The material was a cold-plastic tape manufactured by Prismo. The contract in Jefferson County specified a preformed plastic material (tape) that had a thickness of 60 mils. The material used was the Stamark brand tape manufactured by 3M. The contracts in Fayette County specified a thermoplastic striping material conforming to ASSHTO Specification Designation M249-79. The material was placed at a thickness of 90 mils and involved extruding either hydrocarbon-resin or alkyd-resin thermoplastic material. The first hydrocarbon-resin and both alkyd-resin materials were supplied by Pave-Mark. Material for the second hydrocarbon-resin contract was supplied by Cataphote.

The three original contracts, which were part of the Pavement Marking Demonstration Program, and the second hydrocarbon-resin thermoplastic contract were completed in September 1983. The second and smaller Prismo tape contract was placed in September 1984. The first alkyd-resin thermoplastic contract was placed in November 1984 and the second was placed in September 1985.

Over 163,000 linear feet of 6-inch crosswalks were installed with
about 134,000 linear feet of preformed tape and about 29,000 linear feet of thermoplastic material placed. Over 66,000 linear feet of 24-inch stopbars were installed with about 47,000 linear feet of performed tape and about 19,000 feet of thermoplastic material placed.

Costs of the two types of preformed tapes were similar, but the cost of the extruded thermoplastic stripe was substantially lower. The cost of the alkyd-resin thermoplastic material was slightly higher than that of the hydrocarbon-resin material. Weighted costs (considering unit costs and quantities) for the material found costs for the 6-inch crosswalk were $2.45 per foot for the preformed tapes compared to $1.02 per foot for both hydrocarbon and alkyd thermoplastics. The weighted costs for the 24-inch stopbar were $7.16 per foot for the preformed tapes compared to $2.29 per foot for the hydrocarbon thermoplastic and $3.33 per foot for the alkyd thermoplastic. This shows costs of the preformed tapes were two to three times that of the thermoplastic material.

DATA COLLECTION

Data were collected to evaluate durability, reflectivity, and appearance. Durabilities of the materials were evaluated by periodic visual observations. Evaluations considered the percentage of material remaining on the pavement. There was a 90-day proving period following completion of placement of the marking materials placed as part of the Pavement Marking Demonstration Program. Inspections were conducted by Kentucky Transportation Cabinet personnel, and repairs had to be made at locations at which more than 10 percent of the material failed. Data obtained during the proving periods were used for initial durability information and periodic visual inspections were conducted thereafter.

The second area of evaluation involved the reflectivity of each material. Reflectivity readings were obtained using a portable retroreflectometer. Nighttime observations were also conducted.

Thirdly, the appearance of the materials was evaluated. The contract specified that the material be white, and the maintenance of this color was rated.

ANSI/ASTM D 713-69 was used as a guide in conducting each service test. It describes the rating of traffic paints in terms of appearance, durability, and nighttime visibility. Daytime and nighttime photographs were obtained to document the durability, reflectivity, and appearance evaluations.

RESULTS

DURABILITY

Preformed Tape

All preformed tape installations were placed as part of the Pavement Marking Demonstration Program and were subject to the 90-day proving period. Failures were noted in both Jefferson County (3M
Stamark tape) and Northern Kentucky (two installations of Prismo tape).

The number of feet of tape replaced at each intersection was documented for the Jefferson County installations. Repairs consisted of patching portions of the crosswalk or stopbar that were damaged (Figure 1). Occasionally, the entire line would be replaced. Overall, 16 percent of the total length of stopbars and 18 percent of the total length of crosswalks were replaced. Nearly all intersections (98 percent) received some repair work. The percentage of intersections having crosswalks where either minor or major repairs were made to the crosswalks (92 percent) was higher than the corresponding percentage for stopbars (65 percent).

For the first Northern Kentucky contract, failure of the entire intersection was evaluated and repairs were made when it was judged that more than 10 percent of the material in the intersection had failed. The determination was made that 52 percent of the intersections had over a 10 percent failure. Repairs generally consisted of patching the damaged areas as was done in Jefferson County. An estimate by a Transportation Cabinet engineer was that, overall, approximately 25 to 30 percent of the material failed.

Inspections during the 90-day proving period of the second Northern Kentucky contract (Prismo tape) resulted in identification of numerous durability problems. Extensive corrective work was performed, but durability problems continued. The recommendation was made by the Kentucky Department of Highways that the project be accepted at a reduced price since acceptable performance could not be obtained for a 90-day proving period. A problem noted at locations in this second contract, as shown in Figure 2, involved the loss of large sections of tape due to failure of proper bond at the pavement interface.

Periodic inspections have been made at the original locations for a 30-month period after installation. A durability problem for the Jefferson County installation, using Stamark tape, has existed from the start at locations where there were high-volume turning movements. An example is shown in Figure 3 in the right-turn lane. A patch has been added in the adjacent, through lane. Another problem observed is shown in Figure 4. In the center of the lane, where oil drips from vehicles, bond diminishes. Small bits of tape may be seen around this area similar to that observed around high-volume turning movements. Significant problems were not detected at all locations, as illustrated in Figure 5. Where there were no significant turning movements, the tape was not worn through to the pavement in the wheel paths. Performance was best at the lower volume suburban locations.

Several durability problems were noted with the Prismo material placed under both contracts. Replaced sections of tape experienced the same problem as the original installation. As with the Stamark tape, the Prismo tape experienced problems at locations having high turning volumes. An additional problem involved slippage of the tape, especially at downhill locations (Figure 6), but also at level locations (Figure 7). The Prismo tape has a thickness of 90 mils compared to 60 mils for the Stamark tape, which may account for this problem. When
this slippage occurred, the adhesive would remain in its original position while the tape layer would slide forward so there was a problem of delamination. The problem noted with the Stamark tape, a bond failure where oil dripped onto the tape, was not detected to the same degree, although this problem was noted at some locations. The tape performed generally well at several locations, as illustrated in Figure 8. Wear in the wheel paths through the tape layer down to the adhesive was noted in the inspection after 30 months in service.

The second Prismo contract experienced more durability problems than the first. The most significant problem was a major loss of material due to a lack of adequate bond between the tape and the pavement. Large sections of tape were missing, as shown in Figure 9.

Thermoplastic Material

The first hydrocarbon-resin contract was part of the Pavement Marking Demonstration Program and subject to the 90-day proving period. Inspections during this period did not reveal problems. The major durability problem after the 30-month evaluation period was wear in the wheel path, as shown in Figure 10. This wear was not observed at the lower volume locations. The amount of wear varied substantially at locations having similar volumes. However, it appears that this type of wear will occur after an exposure of approximately five million vehicles per lane (using one-fourth of the total average daily traffic on a four-lane highway to represent traffic per lane). This type of wear was experienced first on crosswalks where a high volume of vehicles were turning. The stopbars and crosswalks still function satisfactorily, even with wear in the wheel paths. However, some markings were painted over in early 1986 after about 30 months in service. There also was a durability problem relating to lack of a bond between the material and the pavement where the pavement was portland cement concrete (Figure 11).

The second and much smaller hydrocarbon-resin contract was the only thermoplastic contract that experienced significant durability problems. The material sustained a substantial amount of wear in the wheel paths as well as minor chipping after only a few months in service. The problem may have been related to the fact that the material was softer than that used in the other hydrocarbon-resin thermoplastic contract (wheel imprints were visible, especially in areas where oil was present).

The first alkyd-resin thermoplastic material applied has been in service about 17 months while the material placed in the second contract has been in place for 6 months. None of the locations have sustained any significant durability problem. There has been some wear at high-volume turning locations, but the durability has typically been very good, as shown in Figure 12.

REFLECTIVITY

Measurements of reflectivity were obtained using a portable retroreflectometer at several intervals after installation of the
various materials. Measurements were taken at approximately 10 intersections for each contract, except the second hydrocarbon-resin thermoplastic contract where measurements were taken at five intersections. Averages of measurements at the various intersections are listed in Table 2.

The Prismo and Stamark tapes and the first hydrocarbon-resin thermoplastic contract had very similar levels of reflectivity. Reflectivity declined substantially at those locations in the first year in service. Measurements verified nighttime observations. Reflectivity measurements of about 100, which is classified as very low, within one year indicate that none of the materials exhibited good long-term reflectivity characteristics. However, the intersections at which the materials were placed were almost always in areas having roadway lighting, so loss of reflectivity would not be as critical.

Nighttime photographs taken a few weeks and about 30 months after placement of each of the materials are shown in Figure 13 through 18. In Figures 13, 15, and 17, the original reflectivity of the materials may be seen. In Figures 14, 16, and 18, the loss of reflectivity is illustrated.

Reflectivity of the second hydrocarbon-resin installation remained slightly better than that placed in the first contract. This is probably related to the lower traffic volumes at the intersections at which the second hydrocarbon-resin material was placed.

The highest reflectivity readings were obtained for material placed in the two alkyd-resin projects. The higher initial readings would probably be related to the amount of drop-on beads applied. Also, the initial measurements were made within a month of installation rather than a few months thereafter. There is a large loss in reflectivity during the first few months as the beads on the surface are lost. This can be noted in the substantial decrease in the readings for the materials placed in the second alkyd-resin contract between October 1985 and April 1986. Initial reflectivity readings for both the tapes and the extruded thermoplastic material would be in the range of 300 to 350. Within a few months, reflectivity measurements would decrease to around 130 to 150, which is similar to measurements on a typical alkyd traffic paint.

Nighttime photographs taken a few weeks and about 17 months after placement of the first alkyd-resin material are shown in Figures 19 and 20.

APPEARANCE

As part of the visual inspection, the overall appearance of the material was noted. This generally involved rating the appearance of the crosswalks when viewed at a distance of at least 10 feet. The color of the material, as compared to the original color, received particular attention. The appearance inspection considered only the material remaining and was not directly related to durability.
Both the 3M Stamark and Prismo preformed tapes maintained their appearance and original color with no significant problem. In Figures 21 through 24, photographs of the material a few weeks and about 30 months after placement are shown. The material had not discolored to a great extent. However, durability problems are evident.

The appearance of a typical hydrocarbon-resin thermoplastic stopbar a few weeks after placement is shown in Figure 25. Typical appearance about 30 months after placement is shown in Figure 26. While the overall appearance of thermoplastic stopbars and crosswalks was satisfactory, a discoloration of the hydrocarbon-resin material was noted between the wheel paths. This was the result of stains from oil dropped from vehicles. This problem was worse at high-volume turning locations (Figure 27). When the thermoplastic material was viewed closely, it could be seen that the surface was covered with small potholes (Figure 28). This may have been the result of the application temperature being too high or from moisture in the pavement. If the temperature was too high, it would have allowed the beads to sink too far into the material and contribute to loss of reflectivity. However, the small holes were not obvious from over a few feet away and did not adversely affect appearance.

Inspections of the alkyd-resin thermoplastic stopbars and crosswalks revealed that they maintained their appearance without the discoloration between the wheel paths associated with the hydrocarbon-resin material. Appearance of the first alkyd-resin material after 17 months in service is shown in Figure 29, and the appearance of the second material after 6 months in service is shown in Figure 30. The alkyd material is chemically incompatible with grease and oil drippings while the hydrocarbon material reacted with the oil and grease, darkening the material. Softening of the material was also noted in the material used for the second hydrocarbon-resin contract where oil and grease had reacted with the material.

SUMMARY

The durability, reflectivity, and appearance of Prismo and 3M Stamark preformed tapes and hot-extruded thermoplastic (both hydrocarbon-resin and alkyd-resin) were evaluated as marking material for stopbars and crosswalks.

Costs of the two preformed tapes were similar but were two to three times the cost of the thermoplastic material. The cost of the alkyd-resin thermoplastic material was slightly higher than that of the hydrocarbon-resin material.

Both preformed tapes experienced initial durability problems with a substantial amount of the material being replaced in the 90-day proving period. The replaced material sustained similar problems. The Stamark tape had significant durability problems in areas of high-volume turning movements as well as in the area between the wheel paths. The Prismo tape had durability problems relating to 1) loss of large sections of tape due to a lack of proper bond between the tape and the pavement and 2) delamination of the tape layer from the adhesive.
The thermoplastic material did not experience those durability problems. It was noted that there was significant wear in the wheel paths after an exposure of approximately five million vehicles per lane (using one-fourth of the total average daily traffic on a four-lane highway to represent the traffic per lane).

All materials sustained a significant loss in reflectivity, but since there was typically roadway lighting present, nighttime delineation was adequate. The highest reflectivity measurements were obtained for the alkyd-resin thermoplastic material, but readings decreased substantially from the initial measurements after a few months.

Both preformed tapes maintained their appearance fairly well as did the alkyd-resin thermoplastic material. The hydrocarbon-resin thermoplastic material sustained some discoloration between the wheel paths, especially in turning lanes, due to oil staining.

IMPLEMENTATION

The alkyd-resin extruded thermoplastic material was determined to be the most cost-effective material for crosswalk and stopbar installations. Installations of this material could be made either by contract or with Kentucky Transportation Cabinet personnel if the necessary equipment was obtained. After a few years, the crosswalks and stopbars must be refurbished to repair wear in the wheel paths. This may be accomplished by adding only the amount of material necessary at any given point to bring the line up to a uniform thickness. Preformed tapes should be used in isolated instances where a stopbar or crosswalk is needed and it is not practical to use the thermoplastic equipment. Preformed tapes also should be used on portland cement concrete pavements until it can be shown that thermoplastic material will have the required durability on this pavement type.
### TABLE 1. SUMMARY OF INSTALLATION CONTRACTS

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### TABLE 2. PORTABLE RETROFLECTOMETER (PRR) MEASUREMENTS

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Figure 1. Patching of 3M Stamark Tape (Main Street and Third Street) in Louisville.

Figure 2. Loss of Sections of Prismo Tape (KY 17 and I 275 WB Ramp in Kenton County).
Figure 3. Durability Problem of 3M Stamark Tape in Turn Lane (US 31W (Dixie Highway) and Lower Hunters Trace in Louisville).

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Figure 16. Nighttime Photograph of 3M Stamark Tape Stopbar after 30 Months in Service (Dixie Highway [US 31W] and Greenwood Road in Louisville).
Figure 17. Nighttime Photograph of Prismo Tape Stopbar a Few Weeks after Placement (US 27 and I 471 in Campbell County).

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Figure 19. Nighttime Photograph of Alkyd-Resin Thermoplastic a Few Weeks after Placement (North Limestone Street and Third Street in Lexington).

Figure 20. Nighttime Photograph of Alkyd-Resin Thermoplastic after 17 Months in Service (Reynolds Road and Lansdowne Drive in Lexington).
Figure 21. Appearance of 3M Stamark Tape a Few Weeks after Placement (Main and Third Streets in Louisville).

Figure 22. Appearance of 3M Stamark Tape after 30 Months in Service (Hurstbourne Lane and Linn Station Road in Louisville).
Figure 23. Appearance of Prismo Tape a Few Weeks after Placement (US 25 at McAlpins Entrance in Kenton County).

Figure 24. Appearance of Prismo Tape after 30 Months in Service (US 25 at McAlpins Entrance in Kenton County).
Figure 25. Appearance of Hydrocarbon-Resin Thermoplastic Stopbar a Few Weeks after Placement (Versailles Road and Mason Headley Road in Lexington).

Figure 26. Appearance of Hydrocarbon-Resin Thermoplastic Stopbar after 30 Months in Service (Tates Creek Road and Albany Road in Lexington).
Figure 27. Oil Staining of Hydrocarbon-Resin Thermoplastic Stopbar (Nicholasville Road and Reynolds Road in Lexington).

Figure 28. Closeup Photograph of Hydrocarbon-Resin Thermoplastic Stopbar (Tates Creek Pike and Albany Road in Lexington).
Figure 29. Appearance of Alkyd-Resin Thermoplastic (First Contract) after 17 Months in Service (Gainesway Drive and Pimlico Parkway in Lexington).

Figure 30. Appearance of Alkyd-Resin Thermoplastic (Second Contract) after 6 Months in Service (Redding Road and Lansdowne Drive in Lexington).