EVALUATION OF PAVEMENT TAPE AS LANE DELINEATION

by

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College of Engineering
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in cooperation with
Department of Transportation
Commonwealth of Kentucky

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16. Abstract

This study involved the field testing of four types of pavement tapes, all manufactured by the 3M Company. The tapes evaluated included Scotchlane, Stamark Removable, Stamark, and an experimental tape. The experimental tape had an extremely high initial reflectivity but poor durability, which would preclude use in its present form. The remaining tapes exhibited good durability when used as lanes and edges. The Scotchlane tape exhibited the best long-term reflectivity. The Stamark tape does not provide sufficient reflectivity and could not be used in areas where delineation would be critical. The Stamark Removable tape was easily removed manually after one or more years of field testing.

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Introduction

Materials used for pavement delineation can generally be grouped into four categories: paints, thermoplastics, raised pavement markers, and pavement tapes. Recent studies by this organization have dealt with each of these materials, except pavement tapes. A study of glass beads for paint stripes was conducted with the objective of evaluating durability and reflectivity of several types of beads (1). Field testing began concurrently with adoption of ultra-fast drying paints in Kentucky and testing efforts were nullified by the fact that beads would not embed adequately in the quick-drying paints. A recommendation of that report proposed experimental applications of three types of beads for further evaluation. Those experimental applications and other tests were subjects of another report on paint-stripe beads (2). Still, inadequate bead embedment resulting from skimming over of quick-drying paint precluded sufficient evaluation. A survey of other states indicated that half of the 42 respondents were having bead embedment problems similar to those experienced in Kentucky. Problems of bead embedment and an evaluation of various bead types are addressed in a continuing study.

In Kentucky, the use of hot-melt, extruded thermoplastics dates back to the early 1950's. The first hot-melt, sprayed thermoplastic material was used to stripe centerlines of the Kentucky Turnpike in 1969. A final report on the series of thermoplastic evaluations in Kentucky was submitted in 1970 (3). All materials used in those applications to that time were hot-melt, extruded thermoplastics having a thickness of about 0.125 inch. A more recent report dealt with evaluation of hot-sprayed thermoplastic stripes on sections of highway in Louisville and Jefferson County (4). Visual observations of appearance, durability, and night visibility revealed that hot-sprayed thermoplastic stripes performed considerably better on bituminous pavements than on concrete pavements.

Initially, it was assumed that thermoplastic striping materials would be a major step toward solution of the rainy, nighttime visibility problem; however, very little evidence is presently available to support that assumption. As a result, recent applications of thermoplastics have been justified as replacements for conventional paint stripes based on durability and economics.

Raised pavement markers have become commonplace for delineation on highways in states where snowfall is minimal and snowplows are not needed. They have proven especially effective for wet, nighttime, and other adverse conditions of visibility where paint stripes are less effective. In Kentucky, over one million raised markers have been installed, and damage from snowplowing has been significant during some of the more severe winters. As a result of costs associated with replacing damaged markers and requirements of the Pavement Marking Demonstration Program, evaluation of installations in Kentucky between 1975 and 1979 was made (5). Installations have included supplements to lane lines and edgelines, replacement of lane lines, and gore area delineation. Another recent report covered use of raised markers at high-hazard locations (6). In addition, use of raised markers as traffic control measures at lane changes was the subject of a study in which their effectiveness in reducing erratic movements was shown (7). A current study involves an evaluation of several types of snowplowable raised markers.

With today's trends in pavement markings pointing toward more durable materials, use of pavement tapes to replace paint stripes is increasing. In addition to durability, their potential effectiveness during rainy, nighttime conditions is another significant dimension. Generally, pavement tapes can be classified as either temporary or regular markings. These two categories and another, which was classified as experimental, were subjects of evaluation included in this report.
Nationwide Usage of Pavement Tape

As part of a national survey of lane delineation methods, uses, costs, warrants, and durability problems of pavement tape were studied (8). Replies from 46 states were summarized. Lane delineations included centerline and edge line markings. Information presented herein represents data collected through mid-1980.

The majority of states has used pavement tape (preformed pliant polymer) as a method of lane delineation to some degree. Of the 46 respondents, 27 (59 percent) indicated some experience with pavement tape. This does not include use of temporary marking tape as a marking in construction zones. Peel-backed construction grade tape, such as Scotchlane, was the most common method of lane delineation used in construction zones. That tape costs about 15 to 20 cents per linear foot of four-inch stripe. Removal of Scotchlane tape presents a problem. The recommended procedure involves heating the tape. The detour grade Stamark tape, which can be removed by hand, has been used by a few states as a temporary tape. However, this tape is expensive, costing approximately one dollar per linear foot of four-inch stripe.

Two types of pavement tape were listed as being used for lane delineation. The most common type was Stamark, which is made by the 3M Corporation. The other type commonly used is the Prismo Plastix tape. The Stamark tape has a thickness of 60 mils; the Prismo tapes are available in thicknesses of 60 or 90 mils. Use of pavement tape for lane delineation is relatively new with a few million feet installed nationwide (about 5 million linear feet reported by respondents with the largest reported usage in Maryland). The average reported cost was about $0.90 per linear foot of four-inch stripe. The latest cost figures for the four-inch, 60-mil tape are in the range of $0.70 to $0.80 per linear foot.

The average useful life of Stamark or Plastix tape was estimated by the respondents to be four years. The useful life may be increased when the tape is inlaid rather than surface applied. The inlay method is used on new asphalt surfaces and involves rolling the tape into the hot asphalt. Several states have used this procedure. The overlay method is used on existing asphalt and concrete surfaces. Of those responding to whether a binder (primer) was used, 25 percent indicated that one was used.

One question on the survey concerned warrants for the use of pavement tape for lane delineation. Ten respondents listed either specific or general warrants used by their state. The warrants primarily covered traffic volumes and pavement type. A summary of these warrants follows:

1. Tape is used in new urban construction projects having an average daily traffic (ADT) over 7,000.
2. Tape is used where it is not cost effective to send striping crews long distances for nominal installations.
3. Tape is used only on bituminous surfaces that will not be resurfaced within the next five years.
4. Tape is used at locations not scheduled for resurfacing within the next four years. On roads where the traffic lanes are at least 12 feet wide, the ADT must be 5,000 vehicles or more per lane. On roads where traffic lanes are less than 12 feet wide, the ADT may be less than 5,000 per lane if there is a past experience of excessive line wear.
5. Tape is used on high-volume two-lane roads having an ADT of over 5,000 and on urban freeways.
6. The minimum ADT should be 2,000. Tape is not permitted on edgelines.
7. Tape is used when the ADT is 1,500 or more and as an alternate to hot thermoplastics.
8. Tape is used on new and existing portland cement concrete pavements that are in good condition. Tape may be used on projects on lighted highways where the retroreflectivity of the marking is not as important and small quantities are involved, resulting in a lower cost.
9. Tape is used at urban signalized intersections.
10. Tape may be used in urban areas on well lighted roads having an ADT...
greater than 11,000 and a speed limit of 35 mph or less. For bituminous pavements, the tape should be inlaid.

One survey question requested a discussion of durability problems encountered with pavement tapes. Generally, the durability of the tapes was rated as good whether or not a binder was used. However, two respondents noted unsatisfactory performance when a binder was not used. The major problem appears to be loss of reflectivity resulting from a loss of beads. Loss of reflectivity in less than one year was noted. Another problem involved damage caused by

snowplowing and studded tires. One state will limit installations to use of the 60-mil thickness using the inlaid process to minimize damage from plowing. The pavement surface may also cause a problem. Poor durability on old pavements and open-graded surfaces was noted. Adhesion failure was noted by one respondent for installations made during cool weather or at locations having very high traffic volumes. Failure under shear and problems when tape moving on the pavement were also listed. In one instance, removal of the tape by vandals was reported.

Installations

Installations were made using four types of tapes, all manufactured by the 3M Company. For the purpose of discussion in this report, the tapes will be referred to as Scotchlane, Stamark Removable, Stamark, and 3M Experimental. A summary of the various installations is presented in Table 1. Included are type of tape, location, date, pavement type, quantity installed, and cost. The first installations of Stamark were made on US 60 in Franklin County in July and August of 1978. Both yellow and white tape were rolled into a bituminous resurfacing project. Later, white lane-line stripes were placed on a concrete section of highway. A binder material was not used for any of the applications. Average cost for the Stamark tape was $0.627 per linear foot, and a total of 23,760 feet were installed. Installation costs included materials, applicator, and technicians for application. Traffic control and a roller were provided by state forces.

Another major installation of Stamark tape was made on I-261 in Jefferson County from July through October 1979. Installation coincided with resurfacing. Only white lane-line stripes were placed. A manually-powered applicator similar to the one shown in Figure 1 was used for installation. Total quantity installed was 21,450 feet and the average cost was $0.88 per linear foot.

The third major installation included Stamark Removable, Scotchlane, and 3M Experimental tapes. Installations were made on I-75 in Fayette County (M.P. 110.9-111.9) in September 1979. A sketch showing the layout of the various types of tapes is presented in Figure 2. Both white and yellow Stamark Removable tape were installed on sections of bituminous and concrete pavements. Most of the Stamark Removable tape was installed on concrete sections (3,090 feet) as compared to the bituminous sections (805 feet). Average cost for the Stamark Removable tape was $0.50 per linear foot. Scotchlane tape was installed on the same section of I-75 in Fayette County. A total of 785 feet was installed on bituminous pavement. Average cost for the Scotchlane tape was $0.223 per linear foot. The third type of tape installed at the I-75 test site was the 3M Experimental tape that had been used on a very limited scale before this evaluation. A total of 1,350 feet was installed on bituminous pavement and 745 feet on concrete.
<table>
<thead>
<tr>
<th>Type of Tape</th>
<th>Installation Location</th>
<th>Date of Installation</th>
<th>Pavement Type</th>
<th>Quantity Installed (linear ft.)</th>
<th>Cost Per Linear Ft. (dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stamark White and Yellow</td>
<td>US 60, Franklin County; M.P. 7.1-8.1</td>
<td>July 17 - 18, 1978</td>
<td>Bituminous</td>
<td>21,384</td>
<td>0.627</td>
</tr>
<tr>
<td>Stamark White</td>
<td>US 60, Franklin County; M.P. 6.0-7.1</td>
<td>August 15, 1978</td>
<td>PCC</td>
<td>2,376</td>
<td>0.627</td>
</tr>
<tr>
<td>Stamark White</td>
<td>I 264, Jefferson County; M.P. 8.2-18.1 WB M.P. 8.2-14.6 EB</td>
<td>July-October 1979</td>
<td>Bituminous</td>
<td>21,450</td>
<td>0.80</td>
</tr>
<tr>
<td>Stamark Removable White and Yellow</td>
<td>I 75, Fayette County; M.P. 110.9-111.9</td>
<td>September 1979</td>
<td>Bituminous</td>
<td>805</td>
<td>0.88</td>
</tr>
<tr>
<td>Scotchlane White and Yellow</td>
<td>I 75, Fayette County; M.P. 110.9-111.9</td>
<td>September 1979</td>
<td>Bituminous</td>
<td>785</td>
<td>0.223</td>
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<td>Scotchlane White and Yellow</td>
<td>I 75, Fayette County; M.P. 110.9-111.9</td>
<td>September 1979</td>
<td>PCC</td>
<td>1,825</td>
<td>0.223</td>
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<td>Experimental 3M (TFE-F-315) White and Yellow</td>
<td>I 75, Fayette County; M.P. 110.0-111.9</td>
<td>September 1979</td>
<td>Bituminous</td>
<td>1,350</td>
<td>1.80</td>
</tr>
<tr>
<td>Experimental 3M (TFE-F-315) White and Yellow</td>
<td>I 75, Fayette County; M.P. 110.9-111.9</td>
<td>September 1979</td>
<td>PCC</td>
<td>745</td>
<td>1.80</td>
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</table>

Figure 1. Manually-powered applicator used for installing Stamark and Stamark removable tapes.
SO UTHBOUND  I-75
LEFT CENTERLINE AND EDGELINE YELLOW WHITE WHITE RIGHT EDGE LINE

<table>
<thead>
<tr>
<th>TYPE</th>
<th>TAPE LENGTH (FEET)</th>
<th>MP 110.9</th>
<th>STAMARK 500</th>
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<tr>
<td>BITUMINOUS</td>
<td>SCOTCHLANE 60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3M EXPERIMENTAL</td>
<td>SCOTCHLANE 300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3M EXPERIMENTAL</td>
<td>STAMARK REMOVABLE</td>
<td>750</td>
<td></td>
</tr>
<tr>
<td>3M EXPERIMENTAL</td>
<td>STAMARK REMOVABLE</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>PCC</td>
<td>SCOTCHLANE 500</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3M EXPERIMENTAL 500</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL LENGTH 5130</td>
<td></td>
<td></td>
</tr>
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</table>

Figure 2. Layout of various tapes at site on I 75 in Fayette County.

Results

Reflectivity Measurements

Reflectivity measurements of the pavement tapes were taken using a reflex photometer. Data are summarized in Table 2. Measurements were made of new tape and samples of tape taken from the roadway after varying periods of service. A sample of tape nine inches long by three inches wide was required. Samples of Stamark Removable and regular Stamark were obtained easily. The Scotchlane tape was not easily removed, but samples were obtained. However, it was very difficult to remove a large enough sample of the 3M experimental tape to conduct reflectivity measurements. A sample of the Prismo Plastix tape could not be obtained. While the Stamark tape was pliable and a large sample could be removed from the pavement, the Prismo tape, which was 90 mils rather than 60 mils thick, was brittle, and a sample large enough for a reflectivity measurement could not be obtained. The tapes were installed on both the centerline and edgeline. The location of the edgeline installation on I 75 was in a construction area, and it received more wear than would normally occur.

The highest reflectivity reading for any tape before installation was for 3M Experimental, which was many times brighter than any other tape. However, after a few months, the reflectivity of the small quantity of 3M Experimental tape remaining was comparable to the other tapes. Scotchlane had the second highest initial reflectivity and maintained its reflectivity better than any other tape. After a few months, the wet reflectivity measurements were similar for each tape, with the highest readings for Scotchlane. The measurements showed that Stamark

Average cost for the 3M Experimental tape was $1.80 per linear foot. Costs for all three types of tape installed in Fayette County included materials, applicator, and technicians for application. A primer was used with the 3M Experimental tape; however, none was used with the other two types.

In addition to the major installations listed in Table 1, several other minor installations were made. These included installations on Newtown Pike in Fayette County, on US 68 in Mercer County, and on Limestone Street in Lexington in front of the Transportation Research Building. The layout and types of tapes tested at these minor installations were not significantly different from the other installations, with one exception. At the US 68 site, one-foot strips of the 3M Experimental tape were placed on the roadway in an attempt to test their effectiveness when compared to raised pavement markers. Raised markers had been installed at this site as part of a previous experimental project (6).
Table 2. Reflectivity Measurements.

<table>
<thead>
<tr>
<th>Type of Tape</th>
<th>Installation Location</th>
<th>Tape Location</th>
<th>Length of Service</th>
<th>Specific Reflectivity*</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dry</td>
</tr>
<tr>
<td>Stamark DNA</td>
<td>DNA  DNA</td>
<td>New</td>
<td>1 Year</td>
<td>.067</td>
</tr>
<tr>
<td>US 60 (Franklin County)</td>
<td>Centerline</td>
<td>2 Years</td>
<td>.025</td>
<td>.021</td>
</tr>
<tr>
<td>AADT = 19,000</td>
<td></td>
<td></td>
<td>.030</td>
<td>.026</td>
</tr>
<tr>
<td>I 264 (Jefferson County)</td>
<td>Centerline</td>
<td>1 Year</td>
<td>.025</td>
<td>.023</td>
</tr>
<tr>
<td>AADT = 87,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scotchlane DNA</td>
<td>DNA  DNA</td>
<td>New</td>
<td></td>
<td>.273</td>
</tr>
<tr>
<td>I 75 (Fayette County)</td>
<td>Edgeline</td>
<td>1 Month</td>
<td>.260</td>
<td>.054</td>
</tr>
<tr>
<td>AADT = 40,000</td>
<td></td>
<td>9 Months</td>
<td>.226</td>
<td>.044</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 Year</td>
<td>.140</td>
<td>.032</td>
</tr>
<tr>
<td>Stamark Removable DNA</td>
<td>DNA  DNA</td>
<td>New</td>
<td></td>
<td>.193</td>
</tr>
<tr>
<td>I 75 (Fayette County)</td>
<td>Edgeline</td>
<td>1 Month</td>
<td>.113</td>
<td>.033</td>
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<td>AADT = 40,000</td>
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<td>9 Months</td>
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<td>.040</td>
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<td>1 Year</td>
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<td>.029</td>
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<td></td>
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<td>.033</td>
<td>.024</td>
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<tr>
<td>Ky 922 (Fayette County)</td>
<td>Centerline</td>
<td>9 Months</td>
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<td>.024</td>
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<tr>
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<td>.022</td>
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<td>DNA  DNA</td>
<td>New</td>
<td></td>
<td>7.05</td>
</tr>
<tr>
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<td>AADT = 40,000</td>
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<tr>
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<td>Prismo HT-90 DNA</td>
<td>DNA  DNA</td>
<td>New</td>
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* Specific reflectivity of a divergence angle of 0.5 degrees expressed as candle power per foot-candle per square foot of material at an incidence angle of 86 degrees.

Removable had a higher initial reflectivity than the regular Stamark tape, and it maintained the higher reflectivity after one year in service. Measurements were made for regular Stamark tape installed at two locations that had quite different traffic volumes. A comparison of reflectivity after one year in service indicated a slightly lower value at the high-volume location (I 264). At the Stamark installation in Franklin County, reflectivity increased during the second year after installation. The lowest initial readings were obtained for the Prismo tapes.

Nighttime Observations

Periodic nighttime observations confirmed some of the reflectivity measurements. Sections of Stamark Removable, Scotchlane, and 3M Experimental tapes were installed on I 75. Initially, the 3M Experimental tape appeared much brighter than the other tapes, followed in brightness by the Scotchlane tape. After a few months in service, the Scotchlane tape appeared brightest followed by Stamark Removable. The high percentage loss of the 3M Experimental tape prevented any meaningful visual comparison of this tape.

Photographs at the various installations were taken during nighttime observations to illustrate reflectivity. Photographs were taken at periodic intervals at the I-75 location. The original reflectivity of the 3M Experimental, Scotchlane, and Stamark Removable tapes are shown in Figures 3-5,
Figure 3. Original reflectivity of 3M experimental tape (I 75, Fayette County).

Figure 4. Original reflectivity of Scotchlane tape (I 75, Fayette County).
Figure 5. Original reflectivity of Stamark removable tape (I 75, Fayette County).

respectively. All tapes appeared bright, but the 3M Experimental tape was exceptionally bright. Photographs were taken at the borders between the 3M Experimental and Scotchlane and between the Scotchlane and Stamark Removable to illustrate the differences in reflectivity. The original brightness of the 3M Experimental tape is shown in Figure 6 (one week after installation) and Figure 7 (one month after installation). The effect of its lack of durability is shown in Figures 8 and 9, which were taken five months and one year after installation, respectively. In those pictures, the border between the tapes is marked by a small piece of tape beside the edgeline. A comparison of Scotchlane and Stamark Removable tapes shows there was minor discernable difference in brightness immediately after installation (Figure 10); however, after one year, the Scotchlane tape was much brighter than the Stamark Removable tape (Figure 11).

To compare the effectiveness of the 3M Experimental tape with raised pavement markers, one-foot strips of tape were applied at regular intervals on a hazardous curve that had previously been a test site for raised pavement markers (6). It was assumed that, since this tape was exceptionally bright, small strips would serve as an alternate to raised pavement markers and would not be subjected to damage by snowplows. As shown in Figure 12, the tape was very effective immediately after installation. However, within a few weeks, almost all of the tape was missing.

Photographs of the Stamark tape installation on US 60 in Franklin County were made one month (Figure 13) and two
Figure 6. Comparison of 3M experimental (foreground) and Scotchlane tapes one week after installation (I 75, Fayette County).

Figure 7. Comparison of 3M experimental (foreground) and Scotchlane tapes one month after installation (I 75, Fayette County).
Figure 8. Comparison of 3M experimental (foreground) and Scotchlane tapes five months after installation (I 75, Fayette County).

Figure 9. Comparison of 3M experimental (foreground) and Scotchlane tapes one year after installation (I 75, Fayette County).
Figure 10. Comparison of Scotchlane (foreground) and Stamark removable tape one month after installation (I 75, Fayette County).

Figure 11. Comparison of Scotchlane (foreground) and Stamark removable tape one year after installation (I 75, Fayette County).
Figure 12. Use of strips of 3M experimental tape at a hazardous curve location (US 68, Mercer County).

Figure 13. Reflectivity of Stamark tape one month after installation (US 60, Franklin County).
years (Figure 14) after installation. There had been a significant loss of reflectivity in that time period, but the tape still provided adequate delineation. The Stamark tape does not provide adequate wet nighttime delineation, as shown in Figure 15. A photograph of the Stamark tape installation on the Watterson Expressway.

Figure 14. Reflectivity of Stamark tape two years after installation (US 60, Franklin County).

Figure 15. Reflectivity of Stamark tape during wet-pavement conditions eighteen months after installation (US 60, Franklin County).
Figure 16. Reflectivity of Stamark tape after one year in service on the Watterson Expressway (I 264) in Jefferson County.

Figure 17. Reflectivity of Prismo tape two years after installation (Rosemont Garden, Lexington).
(I 264) in Jefferson County after one year in service is shown in Figure 16. While the tape was not highly reflective, it provided adequate dry nighttime delineation, particularly where the highway was lighted.

In an attempt to compare the effectiveness of 3M Stamark with another type of pliant polymer tape, a test section of Prismo Plastix was installed by the city of Lexington. The Plastix tape was inspected during both daytime and nighttime conditions. A nighttime photograph is presented in Figure 17. The Plastix tape appears to be similar to the Stamark tape under those conditions. However, data previously presented in Table 1 show the initial reflectivity of Plastix tape is approximately one half that of Stamark tape.

Durability

Photographs of the 3M Experimental, Scotchlane, and Stamark Removable tapes made immediately after the I 75 installation are shown in Figures 18-20.

Figure 18. 3M experimental tape immediately after installation (I 75, Fayette County).

Figure 19. Scotchlane tape immediately after installation (I 75, Fayette County).

Figure 20. Stamark removable tape immediately after installation (I 75, Fayette County).
respectively. In a few weeks, a durability problem with the 3M Experimental tape became evident. As shown in Figures 21 and 22, the top layers of the experimental tape peeled off, resulting in a complete loss of reflectivity as shown in Figures 8 and 9. Figures 23 and 24 show that Scotchlane and Stamark Removable tape exhibited good durability one year after installation. Daytime observations showed both of these tapes remained highly visible after one year of wear and adhesion of these tapes to the pavement was excellent. The only exceptions were a few sections of Stamark Removable tape where bond between the pavement and tape failed (Figure 25). Another problem with the 3M Experimental tape was poor daytime visibility. The tape appeared gray in color and blended with the pavement.

While the removable tape maintained a good bond with the pavement, it was still easily removed by hand. Samples of the Scotchlane tape were removed by hand but not easily. The 3M Experimental tape was almost impossible to remove without also removing a portion of the pavement.

The regular Stamark tape proved to be very durable. All of the tape remained after two years at the Franklin County installation (Figure 26) and daytime visibility of the tape was still good when compared to visibility immediately after installation (Figure 27). The Stamark tape at the Jefferson County site was also very durable one year after installation (Figure 28). While the Stamark tape at these sites became discolored compared to the original white color, it still maintained good daytime visibility. Also, bond between the tape and pavement was

Figure 21. Loss of 3M experimental tape after only a few months (I 75, Fayette County).
Figure 22. 3M experimental tape one year after installation (I 75, Fayette County).

Figure 23. Scotchlane tape one year after installation (I 75, Fayette County).
Figure 24. Stamark removable tape one year after installation (I 75, Fayette County).

Figure 25. Loss of adhesion between Stamark removable tape and the pavement.
Figure 26. Stamark tape two years after installation (US 60, Franklin County).

Figure 27. Stamark tape immediately after installation (US 60, Franklin County).
very good. Samples of regular Stamark were also removed by hand without much difficulty.

Observations of small sections of Prismo tape installed by the city of Lexington showed this tape to be durable (Figure 29). After one year, bond between the tape and pavement remained intact, and the tape had good daytime visibility.

Photomicrographs

To illustrate how the surface of the pavement tape changed, photomicrographs (photographs of a magnified image of a small object) were taken of the tape samples obtained for reflectivity measurements. Specifically, the photographs show the loss of beads from the pavement tape.

Photomicrographs of Stamark tape are shown in Figures 30–34. A new sample of Stamark tape is shown in Figure 30. The beads were not embedded to the optimum depth of one-half their diameter (2). Lack of proper embedment may contribute to a loss of beads and reflectivity. Samples from the installation on US 60 in Franklin County after one month, one year, and two years in service as centerline delineation are shown in Figures 31, 32, and 33, respectively. The beads were retained after one month but were almost completely missing after one year. Samples obtained two years after installation show a new layer of beads becoming exposed. The Stamark tape had beads completely embedded in the tape. In theory, as the beads on the surface are worn or lost, more beads will be exposed as the tape wears. However, there appears to be a gap between loss or wear of the surface beads and exposure of more deeply embedded beads. Close examination of the sample from I 264 in Jefferson County (Figure 34), which was obtained after one year of wear, shows that most original surface beads are missing, but a second layer of beads was only beginning to become exposed. A very
Figure 29. Prismo tape one year after installation (Rosemont Garden, Lexington).

Figure 30. Photomicrograph of new Stamark tape.

Figure 31. Photomicrograph of Stamark tape one month after installation (US 60, Franklin County).
high traffic volume at this site resulted in more wear on the tape, which would expose the embedded beads sooner.

Photomicrographs of Scotchlane tape are shown in Figures 35-38. The new sample shown in Figure 35 indicates that beads are embedded similar to the Stamark tape and greater embedment might improve durability. Bead retention of the edgeline stripe installed on I 75 in Fayette County was very good one month (Figure 36) as well as one year after installation (Figure 37). However, over 50 percent of the beads were missing in the centerline stripe one year after installation (Figure 38).

Photomicrographs of Stamark Removable tape are shown in Figures 39-42. The new sample shown in Figure 39 shows the top layer of beads and the silica particles that were added to improve skid resistance. The top layer of beads had poor embedment characteristics similar to the other tapes. Samples of tape used as edgeline and centerline delineation on I 75 in Fayette County exhibited good bead retention when used as edgeline (Figures

Figure 32. Photomicrograph of Stamark tape one year after installation (US 60, Franklin County).

Figure 33. Photomicrograph of Stamark tape two years after installation (US 60, Franklin County).

Figure 34. Photomicrograph of Stamark tape one year after installation (I 264, Jefferson County).
Figure 35. Photomicrograph of new Scotchlane tape.

Figure 36. Photomicrograph of Scotchlane tape one month after installation as edgeline (I 75, Fayette County).

Figure 37. Photomicrograph of Scotchlane tape one year after installation as edgeline (I 75, Fayette County).

Figure 38. Photomicrograph of Scotchlane tape one year after installation as centerline (I 75, Fayette County).
Figure 39. Photomicrograph of new Stamark removable tape.

Figure 40. Photomicrograph of Stamark removable tape one month after installation as edgeline (I 75, Fayette County).

Figure 41. Photomicrograph of Stamark removable tape one year after installation as edgeline (I 75, Fayette County).

Figure 42. Photomicrograph of Stamark removable tape one year after installation as centerline (I 75, Fayette County).
40 and 41) but less bead retention when used as centerline (Figure 42). Figure 40 shows an edgeline sample one month after installation; Figures 41 and 42 show edgeline and centerline samples, respectively, one year after installation. The sample taken from the centerline after one year of service (Figure 42) showed that some originally obscured beads were becoming exposed.

Photomicrographs of Prismo HR-90 tape in new condition and after one year of service as a lane line at an intersection are shown in Figures 43 and 44. After one year of service, most of the surface beads were gone, but a few other beads were being exposed.

Figure 44. Photomicrograph of Prismo HR-90 tape one year after installation as lane line at an intersection (Rosemont Garden, Lexington).

Conclusions and Recommendations

3M Experimental Tape

Although the 3M Experimental tape had an extremely high initial reflectivity, poor durability precludes use in its current form. In addition to the obviously needed improvement in durability, modifications should include better daytime visibility, a more efficient application procedure, and provisions for easier removal. Also, cost would have to be significantly reduced before there could be any substantial use of the tape.

Stamark Tape

The Stamark tape exhibited good durability on both bituminous and portland cement concrete pavements; however, loss of reflectivity occurred when the surface beads were lost before the embedded beads became visible. Better embedment of the surface beads could improve their durability. Also, a more reflective bead is essential before this tape is used in areas where the delineation provided by the tape would be critical. With the reflectivity provided by the present tape,
it should be limited to roadways that are lighted or have raised markers. Also, high cost of the tape limits its use to high-volume roadways that will not be resurfaced for at least four years. Current costs of $0.70 to $0.80 per linear foot of four-inch stripe for this tape would prevent its use in most places when compared to paint. Other considerations are hazards and delays created by paint striping high-volume roads and loss of reflectivity during winter months when painting is not possible. Volume guidelines that could be used are those developed in a previous evaluation of thermoplastic markings (4). Minimum volumes (AADT) were 15,000 for a two-lane highway, 28,000 for a four-lane highway, and 38,000 for six-lane highways. These volume warrants are higher than those listed by other states.

Scotchlane Tape
Scotchlane tape exhibited the best long-term reflectivity of those evaluated. Durability of the tape was also good when used as centerline and edgeline markings. Durability problems were observed when the tape was used as transverse stripes (9). Adequate embedment could provide better retention of the beads. Considering its relatively low price compared to the other tapes, this tape is the best alternative for marking construction zones. A major improvement toward achieving optimum use as a temporary marking would be an easier method of removal.

Stamark Removable Tape
The Stamark Removable tape exhibited good overall durability on both bituminous and portland cement concrete pavements. Also, the tape was easily removed manually. Reflectivity was initially high and remained very good when used as edgeline and adequate when used as centerline. However, the current high cost of this tape would make widespread use impractical.

Prismo Tape
The small quantity of Prismo tape observed was durable. Bead retention was similar to that of the Stamark tape, but initial reflectivity was less.

References
8. Agent, K. R.; "Survey of Lane