# Evaluation of Construction Zone Pavement Marking Materials

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**Study Title:** Evaluation and Application of Roadway Delineation Techniques Prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration

**Abstract**

The objectives of this report were to evaluate all available foil-back and removable tapes as well as construction zone raised pavement markers and to recommend materials that should be included on approved lists for use by the Kentucky Department of Highways. The tapes were placed on transverse test sections and as lane lines and the reflectivity, durability, and appearance were observed. The markers were observed at test sections as well as at construction sites.

Lists of tapes to be included on the approved lists for foil-back and removable tapes were recommended. Tapes manufactured by 3M and Flex-0-Lite were included on the list of acceptable foil-back tapes. The only recommended removable tape was the 3M removable tape. It was recommended that the Stimsonite 66 construction zone marker could be used if the adhesive is completely removed along with the marker.

**Key Words**
- construction zone
- pavement marking material
- reflectivity
- durability
- pavement tape
- raised pavement marker
- removable

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EVALUATION OF CONSTRUCTION ZONE
PAVEMENT MARKING MATERIALS

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in cooperation with

Kentucky Transportation Cabinet
Commonwealth of Kentucky

and

Federal Highway Administration
US Department of Transportation

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September 1985
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EVALUATION OF CONSTRUCTION ZONE PAVEMENT MARKING MATERIALS

Executive Summary

An alternative to typical paint striping as traffic control during construction and maintenance activities is the use of preformed tapes or, more recently, construction zone raised pavement markers. The objectives of this study were to evaluate all available foil-back and removable preformed tapes as well as construction zone raised pavement markers and to recommend materials that should be included on approved lists.

The reflectivity, durability, and appearance of the tapes were observed periodically at two test locations. Transverse test sections of the tape were placed on both bituminous and concrete surfaces. The tapes also were placed as lane lines. The reflectivities of the tapes were rated using a portable retroreflectometer (PRR). The durability and appearance of the tapes also were observed during each site visit. Also, the removability of the removable tape was tested during each site visit. The reflectivity, durability, appearance, and removability of construction zone markers were also evaluated by observing test sections and markers placed as part of construction projects.

The reflectivity and durability evaluation revealed there was more than one manufacturer who could supply acceptable foil-back tape. Specifically, tapes from 3M and Flex-O-Lite performed adequately while tapes from Swarolite and Cataphote had durability problems. The 3M tapes performed best and the Flex-O-Lite tapes were adequate. There was not a significant difference in performance of the 3M Engineering and Construction Grade tapes. Also, the two Flex-O-Lite tapes (Wet-Reflective and Construction Grade) had similar performance.

The only removable tape which performed adequately was the 3M Removable. The Swarolite Removable and Flex-O-Lite 400 both experienced durability problems.

Of the two construction zone markers tested, the Stimsonite Model 66 marker proved to have adequate durability while the Davidson marker had limited durability. The Stimsonite marker would be used as a supplement to or as a replacement for the temporary tape when provision is made that the adhesive pad be completely removed. Epoxy should not be used to place the markers. The most effective delineation would be a combination of temporary tape and construction zone markers.
INTRODUCTION

Pavement marking is a vital component of traffic control during construction and maintenance activities. An alternative to typical paint striping is the use of preformed tapes or, more recently, construction zone raised pavement markers. When the stripe must be removed, the use of removable tape or markers provides an advantage over traffic paint.

The objectives of this study were to evaluate all available foil-back and removable preformed tapes as well as construction zone raised pavement markers and to recommend materials that should be included on approved lists.

PROCEDURE

PREFORMED TAPE

The reflectivity, durability, and appearance of the tapes were observed periodically at two test locations. Transverse test sections of the tape were placed on US 421 (ADT of 11,000) in Frankfort on August 3, 1984, on both bituminous and concrete surfaces. Daytime and nighttime photographs of the transverse test sections are shown in Figures 1 and 2, respectively. The tapes also were placed as lane lines on the Bluegrass Parkway in Woodford County (ADT of 8,000) on September 17, 1984.

The reflectivities of the tapes were rated using a portable retroreflectometer (PRR). The durability and appearance of the tapes also were observed during each site visit. Also, the removability of the removable tape was tested during each site visit. Seven sets of data were collected at the transverse stripes location over a 234-day period. Seven sets of data also were collected at the lane-line test location over a 238-day period. The durability and appearance of the transverse stripes were observed after 285 days in service.

An effort was made to contact all manufacturers of construction zone preformed tape. Samples from 3M, Flex-O-Lite, Swarolite, and Cataphote were received and evaluated. A sample also was received from Prismo; but their tape was manufactured by another company already in the evaluation so it was not necessary to include it in the evaluation.

CONSTRUCTION ZONE MARKERS

The reflectivity, durability, appearance, and removability of construction zone markers were evaluated by observing 1) test sections placed on the Bluegrass Parkway and on US 421 in Frankfort and 2) markers placed as part of construction projects on I 75 in Whitley County and I 65 in Bullitt County. The Stimsonite Model 66 construction zone marker was placed on both the test sections and the construction projects. A marker manufactured by Davidson Plastics Company was placed on the Bluegrass Parkway. Test sections were placed on the Bluegrass Parkway in September 1984 and May 1985 and on US 421 in August 1984.
RESULTS

PREFORMED TAPE

Summaries of the PRR measurements for the foil-back and removable tapes at the transverse-stripe location are shown in Tables 1 and 2, respectively. PRR measurements of the tapes used as lane lines on the Bluegrass Parkway are shown in Tables 3 and 4.

Measurements showed that all the tapes sustained a significant loss in reflectivity over the evaluation period, especially at the transverse-stripe location. However, some tapes lost reflectivity faster than others.

Considering foil-back tapes, the 3M Engineering and Construction tapes and the Flex-O-Lite Wet-Reflective and Construction tapes maintained reflectivity better than the Swarolite Engineering and Construction tapes or the Cataphote tape. The Swarolite Construction tape lost reflectivity sooner than any other tape. Although the 3M Engineering and Flex-O-Lite Wet-Reflective tapes started with higher reflectivity than their construction grade tapes, within three months the reflectivities of the construction grade tapes were as high or higher. The 3M tapes maintained reflectivity better than the other tapes.

The nighttime reflectivity of the transverse stripes after 130 days in service is shown in Figure 3. The first four yellow stripes are 3M tapes (the first two 3M Engineering and the last two 3M Construction). The appearance of these four stripes are almost identical. There is a distinct loss in reflectivity for the next four stripes, which are Swarolite Engineering (first two) and Swarolite Construction. Then there is an increase in reflectivity of the next four stripes, which are Flex-O-Lite Wet Reflective (first two) and Flex-O-Lite Construction. The reflectivity of the next two stripes, which are Cataphote Catatape, drops off dramatically. The last two stripes provide increased delineation compared to the Cataphote or the Swarolite tapes. This tape was distributed by Prismo but was not included in the evaluation since Prismo does not manufacture the tape. It should be noted that the 3M tapes are the only tapes that did not show significant loss in reflectivity in the wheel paths.

PRR measurements of the removable tape (Tables 2 and 4) show that the 3M Removable tape maintained the highest reflectivity for both yellow and white tapes. The yellow Swarolite Removable maintained a comparable reflectivity, but the white did not. The Flex-O-Lite 400 experienced a very early loss in reflectivity.

During each inspection, the durability and appearance of the tapes were noted. The appearance of the tapes was related to the durability. As the tapes experienced wear, its appearance worsened. The ranking in terms of durability of the various foil-back and removable tapes was the same as found for the reflectivity.

Shown in Figures 4 through 10 are photographs illustrating the
durability and resulting appearance of the foil-back tapes after 285 days in service as transverse stripes. The 3M tapes, as shown in Figures 4 and 5, provided the best durability with only slight wear. There was little difference between the construction grade and the thicker engineering grade tapes. The Flex-O-Lite tapes, as shown in Figures 6 and 7, also provided adequate durability with moderate wear. The Flex-O-Lite construction grade tape experienced slightly more wear than the wet reflective. Both Swarolite tapes experienced heavy wear as shown in Figures 8 and 9. The Cataphote tape also experienced heavy wear along with bonding failure between the adhesive and the pavement (Figure 10).

Of the removable tapes, only the 3M Removable provided acceptable durability. After 285 days in service at the transverse stripe location, it had experienced only slight wear and its appearance was very good (Figure 11). A problem with the Swarolite Removable was a failure in bonding between the adhesive and the pavement (Figure 12). The Flex-O-Lite 400 Removable tape experienced heavy wear within a short time after its placement, as shown in Figure 13 and as previously documented by the PRR measurements.

The ease of removal for the three removable tapes was investigated along with the length of time necessary for the stain or mark left after removing the tapes to disappear. The 3M and Swarolite removable tapes were removed easily in most instances. One exception was when the tapes were removed on a very cold day (30 degrees Fahrenheit). Under cold weather conditions, the tapes were brittle and had to be removed in small pieces. Also, the tapes became more difficult to remove at the transverse-stripe location after several months in service. The Flex-O-Lite 400 tape could not be removed in the wheelpath at the transverse-stripe location within one month of installation and could only be removed at the extreme edges of the lanes after two months in service.

The mark left by both the 3M and Swarolite removable tapes disappeared within one to two months at the transverse-stripe location. Figure 14 is a photograph showing the mark left by the 3M Removable tape immediately after removal (on the right) and the very slight evidence of such a mark two months after removal (on the left).

CONSTRUCTION ZONE MARKERS

A test section that included both the Stimsonite 66 and Davidson markers was placed on the Bluegrass Parkway in May 1985 and monitored for approximately four months. A total of 71 Stimsonite and 31 Davidson markers were placed next to the yellow edgeline, and 120 Stimsonite and 10 Davidson markers were placed between the lane lines.

The durability of the Stimsonite 66 markers was adequate and no major damage was observed. Minor cracking was noted in about nine percent of the edgeline markers and ten percent of the lane-line markers after about four months in service. The Davidson marker had no durability problems after one month; but within two months of installation, about one third of the markers had split substantially at the base of the top flap. This resulted in the flap laying over as
shown in Figure 15. After four months, all of the markers were experiencing some sort of durability problem.

The removability of the Stimsonite 66 and Davidson markers was checked as part of the Bluegrass Parkway test. Lane-line and edgeline markers were removed each month. The Davidson marker was not difficult to remove, but a portion of the adhesive remained and this was not acceptable (Figure 16). The Stimsonite 66 markers were placed without a primer since they were placed on an asphalt pavement that was in good condition and the air temperature was about 83 degrees Fahrenheit at the time of installation. Even without the primer, the markers were not easy to remove. Specifically, the pad was difficult to remove. A flat shovel was used, in most instances, to remove the markers. In many instances, the marker would become separated from the pad, and it would require substantial effort to remove the pad. Better success was achieved when a heavier instrument, similar to a very long chisel, was used. It appears that, with a properly designed device, the marker and pad could be removed without an unreasonable amount of effort. A pavement scar was left initially, but after a couple of months, the scar was not unacceptable if the pad was completely removed (Figure 17).

From one to five Stimsonite markers were placed between the lane lines to determine the number necessary to supplement tape or to simulate a skip line. Another test was conducted in which three to five markers were placed so as to simulate a 10-foot stripe on a section of pavement that had no other markings. Using both sets of input, it was determined that four markers, placed on a 3 1/3-foot spacing, could adequately simulate a 10-foot skip line (Figure 18). One marker placed between each skip line, a 40-foot spacing, would be adequate to supplement tape.

The edgeline markers were placed at 5-foot and 10-foot centers. To adequately simulate a solid line, the 5-foot spacing is necessary. The left edgeline markers shown in Figure 19 show a 10-foot spacing followed by a 5-foot spacing. The markers placed at the 5-foot spacing appear as a solid line. Also shown in Figure 19 is the nighttime delineation provided by the Stimsonite 66 markers placed at a 40-foot spacing between lane lines. When used to supplement preformed tape as an edgeline, a 10-foot spacing is adequate.

The performance of the Stimsonite 66 construction zone markers when used on construction projects on I 75 in Whitley County and I 65 in Bullitt County was monitored. On the I-75 project, either 3M Removable tape or Stimsonite 66 markers (placed at 5-foot spacings) were used as an edgeline taper at lane closures. The daytime and nighttime delineation provided by the 3M removable tape is shown in Figures 20 and 21, respectively. The daytime and nighttime delineations provided by the Stimsonite 66 markers are shown in Figures 22 and 23, respectively. While both devices provided adequate delineation, the 3M Removable tape provided better daytime delineation and the Stimsonite 66 markers provided better nighttime delineation. A combination of the two devices would provide optimum delineation. The tape was removed easily and after a few weeks left no visible mark (as shown in Figure 24). The markers were removed with a grader, which resulted in the marker being
removed while leaving the pad. As shown in Figure 25, the pad remained on the pavement after one year of wear by interstate traffic (ADT of 21,000). The markers were placed with and without the primer, but the pad remained on the pavement when removed by a grader (Figure 26). This shows that the marker and pad must be removed manually unless a better technique using a machine is developed.

The Stimsonite 66 markers were placed on 4-foot spacings (without a primer) next to a temporary median barrier to simulate a yellow edgeline on the I-65 construction project (ADT of 30,000). The nighttime photograph shown in Figure 27 shows that the markers provided good nighttime delineation. Low-profile Stimsonite markers installed on 40-foot spacings were used to supplement the 3M Removable tape, which was used for the lane lines. The daytime photograph shown in Figure 28 was taken about seven months after installation. It shows that the markers have shown excellent durability and provide adequate daytime delineation.

The Stimsonite 66 markers also were installed with a bitumen material as the adhesive at the first Bluegrass Parkway test section (Figure 29). The problem of removal was similar when using either the bitumen material or the adhesive pad. About nine months after being removed by a snowplow, the bitumen remained on the road surface in nearly the same condition as the adhesive pads (Figure 30).

SUMMARY AND CONCLUSIONS

PREFORMED TAPE

The reflectivity and durability evaluation revealed there was more than one manufacturer who could supply acceptable foil-back tape. Specifically, tapes from 3M and Flex-O-Lite performed adequately while tapes from Swarolite and Cataphote had durability problems. The 3M tapes performed best and the Flex-O-Lite tapes were adequate. There was not a significant difference in performance of the 3M Engineering and Construction Grade tapes. Also, the two Flex-O-Lite tapes (Wet-Reflective and Construction Grade) had similar performances.

The only removable tape which performed adequately was the 3M Removable. The Swarolite Removable and Flex-O-Lite 400 both experienced durability problems.

Additional tests should be conducted periodically to update the list of approved tapes. Since approximately one year is required to evaluate and report on each test, a two-year testing cycle would appear reasonable.

CONSTRUCTION ZONE MARKERS

Of the two construction zone markers tested, the Stimsonite Model 66 marker proved to have adequate durability while the Davidson marker had limited durability. The Stimsonite marker could be used as a supplement to or as a replacement for the temporary tape when provision is made that the adhesive pad be completely removed. Epoxy should not
be used to place the markers.

The most effective delineation would be a combination of temporary tape and construction zone markers. The tape provides better daytime delineation while the markers provide better nighttime delineation, especially during hazardous rainy, nighttime conditions. When used as a supplement, the markers should be placed on 40-foot spacings for a skip line and on 10-foot spacings for a solid line. If used as a replacement for temporary tape, the markers should be placed at 5-foot spacings to represent a solid line, and a set of four markers placed at 3 1/3-foot spacings should be used to represent a 10-foot skip line.

IMPLEMENTATION

The following tapes are recommended to be included on the approved list for foil-back construction tape:

1. 3M Engineering Grade (5360 and 5361)
2. 3M Construction Grade (5160 and 5161)
3. Flex-O-Lite Wet-Reflective
4. Flex-O-Lite Construction Grade

The 3M and Flex-O-Lite Construction Grade tapes do not meet the specifications currently listed in Section 831 of Kentucky's Standard Specifications for Road and Bridge Construction (1985 Edition). This specification could be changed by modifying the thickness requirement and replacing the laboratory durability test with a field performance test. The field performance test would involve placing transverse test sections of tape at a two-year interval for an approximate one-year testing period.

The only tape recommended to be included on the approved list for removable construction tape is the 3M Removable (5710 and 5711).

The Stimsonite 66 marker is the only marker recommended to be included on the approved list for construction zone raised pavement markers. It is to be used only when provision is made in the contract that the adhesive be completely removed along with the marker.

For the most effective delineation in construction zones, it is recommended that construction tape be used in conjunction with construction zone markers.
### TABLE 1. PRR MEASUREMENTS FOR FOIL-BACK TAPE
(TRANSVERSE STRIPES)

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### TABLE 2. PRR MEASUREMENTS FOR REMOVABLE TAPE
(TRANSVERSE STRIPES)

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TABLE 3. PRR MEASUREMENTS FOR FOIL-BACK TAPE  
(LANE LINES ON BLUEGRASS PARKWAY)

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TABLE 4. PRR MEASUREMENTS FOR REMOVABLE TAPE  
(LANE LINES ON BLUEGRASS PARKWAY)

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<td>3M Removable (5710)</td>
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Figure 1. Transverse Test Section.

Figure 2. Nighttime Photograph of Transverse Test Section Four Days after Placement.
Figure 3. Nighttime Reflectivity of Transverse Stripes after 130 Days in Service.

Figure 4. 3M Engineering Tape after 285 Days in Service.
Figure 5. 3M Construction Tape after 285 Days in Service.

Figure 6. Flex-O-Lite Wet Reflective Tape after 285 Days in Service.
Figure 7. Flex-O-Lite Construction Tape after 285 Days in Service.

Figure 8. Swarolite Engineering Tape after 285 Days in Service.
Figure 9. Swarolite Construction Tape after 285 Days in Service.

Figure 10. Cataphote Tape after 285 Days in Service.
Figure 11. 3M Removable Tape after 285 Days in Service.

Figure 12. Failure in Bonding between Swarolite Removable Tape Adhesive and Pavement.
Figure 13. Wear to Flex-O-Lite Removable Tape after 90 Days in Service.

Figure 14. Mark Left by 3M Removable Tape Immediately after Removal (on Right) Compared to Very Slight Evidence of Marks Two Months after Removal (on Left).
Figure 15. Durability Problem of Davidson Marker.

Figure 16. Adhesive Left on Pavement after Removal of Davidson Marker.
Figure 17. Slight Pavement Scar Two Months after Removal of Stimsonite 66 Marker and Pad.

Figure 18. Four Stimsonite 66 Markers Placed on 3-1/3 Foot Spacings to Simulate a 10-Foot Skip Line.
Figure 19. Reflectivity Provided by Stimsonite 66 Markers Placed on 40-Foot Spacings on the Lane Line and 10-Foot Followed by 5-Foot Spacings on the Left Edgeline.

Figure 20. Daytime Delineation Provided by the 3M Removable Tape.
Figure 21. Nighttime Delineation Provided by the 3M Removable Tape.

Figure 22. Daytime Delineation Provided by Stimsonite 66 Markers Placed on 5-Foot Spacings.
Figure 23. Nighttime Delineation Provided by Stimsonite 66 Markers Placed on 5-Foot Spacings.

Figure 24. Lack of Any Mark on the Pavement a Few Weeks after Removal of 3M Removable Tape.
Figure 25. Pads Remaining on Pavement One Year after Removal of Stimsonite 66 Markers.

Figure 26. Pads Remaining on Pavement after Removal of Stimsonite 66 Markers with Grader (Markers on Left Placed without Primer while Markers on Right Placed with Primer).
Figure 27. Nighttime Delineation Provided by Stimsonite 66 Markers Placed on 4-Foot Spacings on the Left Edgeline, 3M Removable Tape Used for the Lane Lines, and Low-Profile Stimsonite Markers on 40-Foot Spacings between Lane Lines.

Figure 28. Durability of Stimsonite 66 Markers about Seven Months after Installation.
Figure 29. Installation of Stimsonite 66 Markers Using Bitumen.

Figure 30. Bitumen Remaining on Pavement about Nine Months after Removal of Stimsonite 66 Markers.