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RESEARCH UPDATE

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COMPARISON OF PAVEMENT MARKING SYSTEMS
WATERFORD-LYNDON, I-91

References Initial Report 1998-2, Category II Work Plan 96-R-4, Waterford-Lyndon IM091-3(7) Project

Background

In the fall of 1997 the Vermont Agency of Transportation (VAOT) initiated a study into the field performance of three pavement marking systems: thermoplastic, epoxy, and waterborne paint. The materials were installed contiguously on newly placed open graded friction course (OGFC) bituminous concrete on Interstate 91 in the Town of Lyndon, Vermont. The applications under study are 4" (100 mm) white edge lines and yellow barrier lines. The lines were tested for retroreflectivity, skid resistance, and overall quality of appearance when they were placed in 1997. The focus of this study is to evaluate these materials under exposure to identical conditions and to use these data to better understand their relative performance. A primary feature of this study is to examine the effects of snow plowing on the subject materials.

This report details the inspection performed this spring and presents conclusions regarding the materials' performance over one winter of exposure.

Inspection

The subject materials were inspected on May 1, 1998 by VAOT Research and Development personnel. The materials were examined for wear and tested for retroreflectivity and skid resistance. Unfortunately, readings from the British pendulum skid tester were found to be inconsistent, indicating that the instrument is in need of calibration. Therefore, this feature of the investigation will have to be performed at a later date.

Thermoplastic

The yellow and white thermoplastic lines were in good condition at both test sites, with very little loss of material over the past winter. Plow damage was minimal, but as expected, the drop-on glass beads were gone from the surface. Since it is anticipated that snow plowing will obliterate the drop-on beads, additional beads are intermixed in the material so that they become exposed as the thermoplastic material wears away, insuring that the markings will continue to be retroreflective. During the field inspection it was noted that the imbedded beads were not readily visible on the surface of the thermoplastic material. The absence of exposed glass beads was corroborated by retroreflectivity readings. The white lines had an average loss of retroreflectivity of 64% over one winter. The yellow lines held up better, with a loss of 26%. (see Table 1).

The lack of surface beads could be due to an insufficient quantity of intermixed beads or the beads may have failed to remain in suspension, having settled to the bottom of the liquefied material when it was applied. Another possibility is that not enough material has been worn away to expose the underlying beads, in which case retroreflectivity readings could actually improve over another winter of plowing. In any case, the thermoplastic markings are in good condition in spite of the sharp drop in retroreflectivity.

Epoxy

As shown in Table 1, the initial readings taken on the epoxy lines showed them to have superior retroreflectivity to thermoplastic, especially the yellow lines. But over the past winter the surface of the epoxy markings were badly chipped (see Photo addendum). Approximately 30% of the epoxy on the surface was gone, but material lying in the recesses of the aggregate was intact. Since the lost surface material was chipped off rather than worn or faded, the loss was attributed to plow strikes. The epoxy markings have also dropped considerably in retro-reflectivity, averaging a 54% loss on the white lines and 62% on the yellow. Surprisingly, the epoxy markings are exhibiting retroreflectivity comparable to the thermoplastic markings in spite of the loss of material.

Waterborne

The waterborne lines had particularly low initial values for retroreflectivity, especially on the white lines, where bleed-through was suspected. The material has worn badly over the past winter (see photo addendum). Given the low initial readings and the loss of material over the past winter, this application is considered to be at the end of its service life.

Table 1. Retroreflectivity (mcdls)

Material/ Test Site	Oct. '97 White	Oct. '97 Yellow	May '98 White	May '98 Yellow	% Loss* White	% Loss* Yellow
Thermo						
MM 130.50	222	90	77	68	-65	-24
MM 134.75	177	80	67	57	-62	-29
Epoxy						
MM 133.45	232	192	83	49	-64	-74
MM 133.55	110	194	58	97	-47	-50
Waterborne						
MM 133.70	39	145	14	28	-64	-81
MM 134.00	45	96	12	21	-73	-78

* Denotes loss of retroreflectivity, not material
Each value represents an average of five readings

Material Compatibility with Open Graded Friction Course

Of the three materials under study, waterborne traffic paint proved to be the least effective. Initial readings were particularly low on the white lines, probably a result of bleed-through from the newly placed OGFC pavement. The markings were poorly visible after less than one half year of service. In appears that the coarse OGFC pavement, with its high concentration of voids, does not accept a thin 15 mil (380 μm) application of waterborne paint as well as a smoother surfaced dense graded mix. Waterborne paint tends to pool in the recesses of the OGFC pavement when applied, causing the surface area of the markings to be thin and susceptible to weathering and wear.

The epoxy markings did not show bleed-through and formed a good bond with OGFC. The color of the material was bright and initial retroreflectivity readings were excellent. Over the past winter the material was badly chipped by plowing, with a loss of material of approximately 30%. The epoxy markings are currently providing adequate retroreflectivity; but given the extent of plow damage, it is anticipated that the markings will be exhausted after another winter. Based on these observations it is the opinion of the researchers that the recommended application thickness of 15 mils (380μm) is too thin for use on OGFC, for the same reasons described for use of waterborne paint.

The thermoplastic lines are exhibiting the best durability, although retroreflectivity is inexplicably low. The markings held up well to plowing over the past winter. The only damage was some minimal chipping at the edges and an occasional dislodged piece of aggregate.

As noted in the initial report, pavement raveling has been noted on prior projects where thermoplastic lines are placed on OGFC. It has been previously hypothesized that thermoplastic blocks the voids in OGFC and hinders proper drainage, making the pavement susceptible to freeze/thaw damage. Another hypothesis is that thermoplastic forms such a strong bond in the OGFC voids that if a plow lifts up thermoplastic, it takes up pavement as well. So far neither of these cases has been observed on the subject thermoplastic markings. Although some plow damage to the pavement has occurred, it has been attributed to misadjusted plow shoes and/or plow operator error and is not related to the markings.

The application thickness of thermoplastic on this project was 90 mils (2.3 mm). In previous years the application thickness employed was 125 mils (3.2 mm). It is conceivable that the reduction in material has afforded a lower profile, which in turn has reduced plow contact and subsequent damage. As noted in the inspection section of this report, the thermoplastic lines do not appear to have been seriously scraped by plowing. The reduction in application thickness may prove to be beneficial in extending the service life of the markings as well as mitigating adverse effects on OGFC pavement.

Summary

The following initial findings were gained from the spring 1998 inspection. In terms of durability, waterborne traffic paint fails to provide a reflective line for a full winter of service. For this reason, use of waterborne traffic paint on interstate highways should only be employed as temporary markings or as a maintenance treatment for existing thermoplastic lines, as is VAOT's current practice.

The epoxy markings provided good color and retroreflectivity, but proved susceptible to chipping by snow plows. The 15 mils (380 μm) application used on this project may actually be inadequate in thickness for this wearing surface. Use of epoxy on dense graded mix in Vermont has proved much more durable than on the open graded mix of this project. Therefore, it is recommended that the application thickness of epoxy be increased if used on OGFC, as this may strengthen the material's bond to the surface of the pavement and extend its useful life.

Thermoplastic is providing the best resistance to weathering and winter maintenance. The lower profile used on this application may actually be extending the service life of the material, although the imbedded intermix of glass beads is not highly visible on the surface, which accounts for the lower than expected retroreflectivity readings.

Follow Up

The waterborne paint test section is at the end of service life and will be replaced this year by thermoplastic markings. Therefore, there will no more data collected from this application.

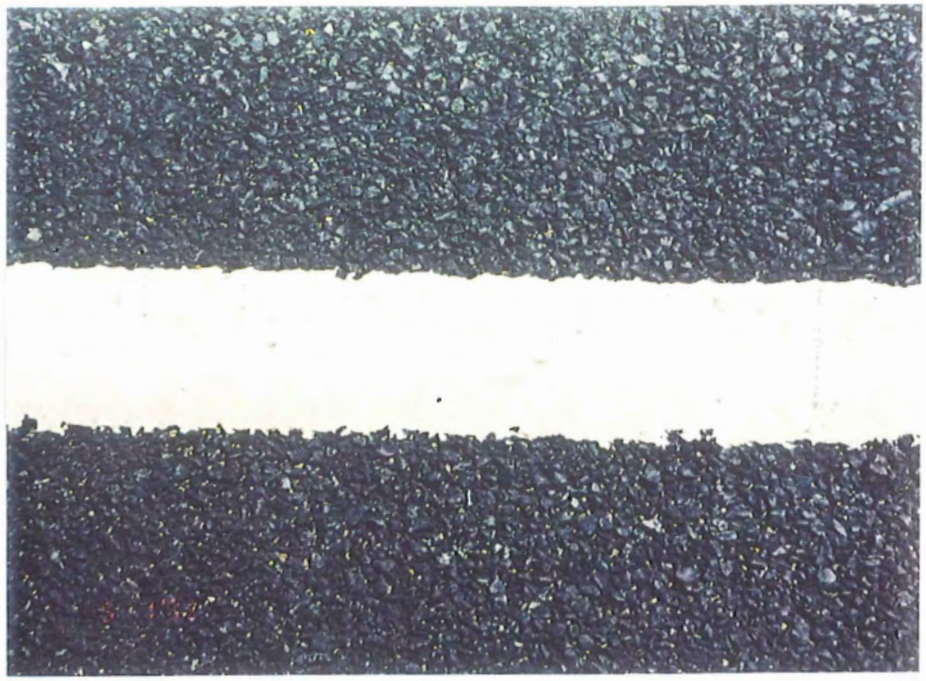
The epoxy markings are badly chipped, even though retroreflectivity readings indicate that the lines are adequately visible for continued service. As of the date of this report it is not certain if the epoxy lines will be replaced this summer. Should the lines remain in service they will be inspected again next spring.

The surviving lines will be inspected next spring and an update report will be issued.

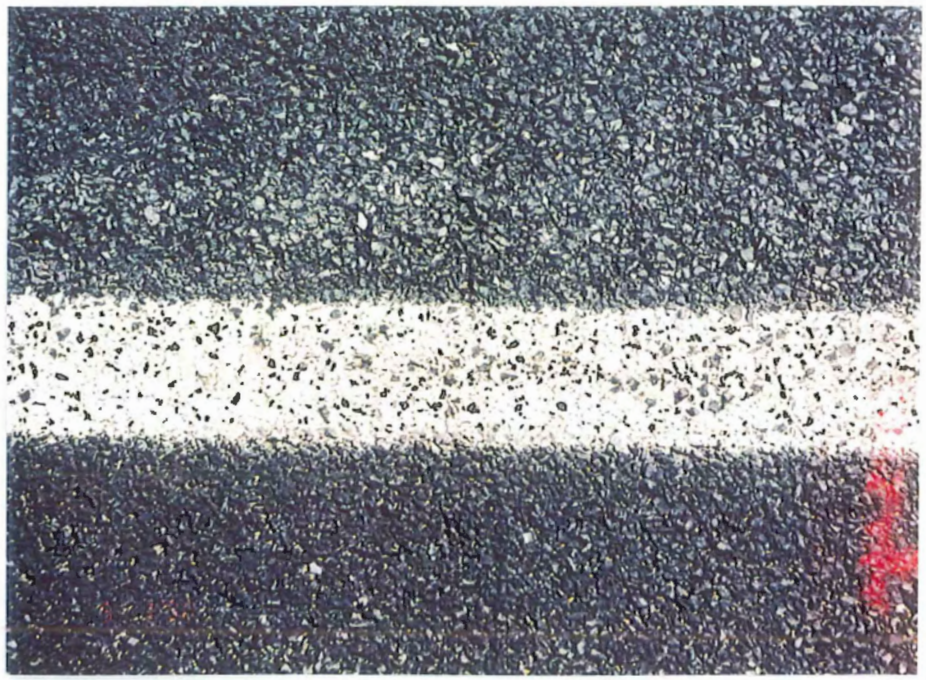
Photo Addendum

Pavement markings after seven months of service

Thermoplastic edge line
MM 134.75



Epoxy edge line
MM 134.50



Waterborne edge line
MM 134.00