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A Summary of New York's Research On Pavement Marking Materials

RONALD A. LORINI

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ENGINEERING RESEARCH AND DEVELOPMENT BUREAU
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A SUMMARY OF NEW YORK'S RESEARCH ON PAVEMENT MARKING MATERIALS

Ronald A. Lorini, Civil Engineer I

Final Report on Research Project 157-1
Conducted in Cooperation with
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16. Abstract

This report summarizes New York's research on pavement marking materials from 1978 through 1989. Two-component epoxy, thermoplastic, preformed tape, polyester, and epoflex pavement markings were evaluated under this project. All the markings provided service life from 2½ to 4 years, except for epoflex markings which exhibited premature adhesion failure. The five Research Reports summarized here are available to interested readers on request.

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

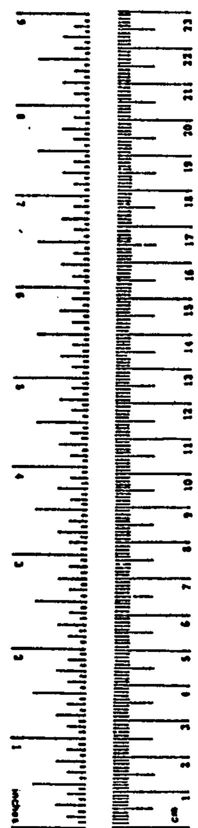
Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
in	inches	2.54	millimetres	mm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
	AREA			
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.0929	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
mi^2	square miles	2.59	kilometres squared	km^2
ac	acres	0.395	hectares	ha
	MASS (weight)			
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
	VOLUME			
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft^3	cubic feet	0.0328	metres cubed	m^3
yd^3	cubic yards	0.0765	metres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

TEMPERATURE (exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

* SI is the symbol for the International System of Measurements



APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
	AREA			
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
km^2	kilometres squared	0.39	square miles	mi^2
ha	hectores (10 000 m^2)	2.53	acres	ac
	MASS (weight)			
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T
	VOLUME			
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3

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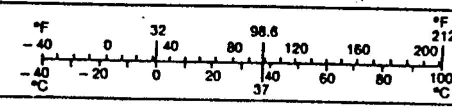

These factors conform to the requirement of FHWA Order 5190.1A.

CONTENTS

I. INTRODUCTION

The standard marking material in New York State has long been a hot-applied modified-alkyd traffic paint. With increased traffic volume, its durability often becomes unsatisfactory. By the late 1970s, some heavily traveled highways did not have good continuous lane delineation, even with repainting twice a year. Also, wet-night visibility of the paint stripe was poor because retroreflective beads were covered with water.

In 1979, New York State Department of Transportation adopted a policy requiring use of more durable markings on most newly constructed pavements and on some existing pavements. With a range of durable marking materials available, their advantages compared to standard traffic paint became obvious, in terms of providing good year-round pavement delineation without frequent restriping. A number of durable pavement-marking materials were evaluated. Performance evaluation of thermoplastic, epoxy, preformed tape, epoflex, polyester, and an overview of New York's pavement marking policy were documented in a series of five interim reports (1,2,3,4,5). The purpose of this final report is to provide a summary of research in the 1980s and to complete requirements of the Federal Highway Administration's Highway Planning and Research Program. Results are summarized for each of the five reports, including the abstract and conclusions.

II. DURABLE PAVEMENT MARKINGS

A. Evaluation of Long-Life Pavement Markings (1)

Included are three types of durable marking materials:

1. Thermoplastic,

2. Epoxy, and

3. Preformed tape.

Application procedures, cost analyses, and performance evaluations, in terms of durability and reflectivity, are described in this report.

1. Abstract

This report describes installation and performance of several large installations of durable pavement markings. Thermoplastic, two-component epoxy, and one brand of preformed-tape marking materials provided 4 or more years of service in longitudinal applications. Heavy snowplow damage in some cases reduced the ultimate service life of 125-mil extruded-thermoplastic markings. Some premature failure resulted on the first New York State installation of two-component epoxy, and on one brand of preformed tape installed on tine-textured concrete pavement. Most installations of two-component epoxy provided good reflectivity throughout their lives. Preformed tapes and thermoplastic provided good initial reflectivity, but night visibility dropped as surface beads were lost. It appears that insufficient matrix beads were included to provide good reflectivity throughout the service life of these preformed-tape and thermoplastic markings.

2. Conclusions

Based on performance of pavement marking materials evaluated under this study, the following findings can be stated:

1. Thermoplastic, two-component epoxy, and one brand of preformed-tape pavement-marking materials are capable of providing 4 years or more of service in longitudinal applications.

2. Heavy snowplow damage on the 125-mil extruded thermoplastic reduced its service life, and its resulting overall durability was about equivalent to 60- and 90-mil sprayed lines.

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3. Several areas of premature failure occurred on the first epoxy installation. Subsequent modifications to the application equipment appeared to remedy this problem.

4. Epoxy installed during light rain and over worn paint lines suffered no apparent loss of serviceability.

5. "Plastix" preformed-tape markings installed on tine-textured concrete pavement suffered severe delamination and bond failure over the first winter.

6. Most epoxy markings provided good reflectivity throughout their service lives.

7. Thermoplastic markings initially provided good reflectivity, but declined to "poor" before the end of their service lives. This loss of reflectivity is attributed to insufficient matrix beads initially, aggravated by their damage and loss.

8. Both brands of tape provided good initial reflectivity. Surface beads on one were lost quickly and poor reflectivity resulted, but the other has retained sufficient surface beads to ensure acceptable reflectivity for its first 2 years in service. However, it too is expected to deteriorate eventually to poor reflectivity because of insufficient matrix beads.

9. Deterioration of the asphalt pavement along longitudinal lane and shoulder joints led to premature loss of thermoplastic markings in some areas.

B. Reflectivity and Durability of Epoxy Pavement Markings (2)

A total of 16 projects placed between 1978 and 1984 were surveyed. They were located throughout the state, and included varied roadways, pavement types, traffic volumes, and surroundings. This report summarizes results of the performance survey in terms of durability and reflectivity.

1. Abstract

Epoxy pavement markings on 16 projects were surveyed to determine durability and reflectivity. These markings were up to 6 years old, and were installed on both portland cement and asphalt concrete pavements. Most were in good condition, and were providing acceptable daytime delineation. Although most markings also had fair or good reflectivity, some were not providing acceptable reflectivity, but most of the poor service occurred on a few recent projects. It was not possible to relate differences in condition or reflectivity to roadway characteristics, traffic, striping contractor, or material supplier, and it appears that these differences are attributable to particular characteristics of each installation.

2. Conclusions

Based on this survey of 16 epoxy striping projects, the following findings appear warranted:

1. Most projects inspected were in fair to good condition. While some striping material has been lost, most still provide an acceptable level of daytime delineation.

2. Most projects surveyed provide fair-to-good reflectivity, but about one-third were marginal or unacceptable. Most markings with marginal or unacceptable reflectivity were located on only a few projects, some only 1 year old.

3. Several parameters appeared to be associated with increased wear or lower reflectivity, but these apparent trends may be related to poor performance noted on a few projects, which introduced bias into the analysis.

4. A larger survey of epoxy markings in service over a longer period is needed to identify causes of the marginal performance noted on a few projects.

C. Evaluation of Epoflex Pavement Markings (3)

This new pavement marking material was developed at Southwest Research Institute. It consisted of epoxy resins, pigment, calcium carbonate, and glass beads. The resins used are a thermoplastic which liquifies at a high temperature (450 F) but otherwise remains solid at ambient temperatures. Some advantages are low cost, extremely quick dry-times, good reflectivity, and good adhesion to both concrete and asphalt pavements. New York State decided to evaluate the application procedure and performance of two large installations, because of its potential advantages over epoxy and thermoplastic marking materials already in use.

1. Abstract

This report documents installation and performance of epoxy thermoplastic pavement marking material -- also knows as "epoflex" or "EPT" -- in New York. Two large contracts, totaling 1,275,000 lin ft of white and yellow markings, were placed on asphalt and concrete pavements. Both installations proceeded smoothly, and line quality and initial delineation by day and by night were excellent. Unfortunately, long-term performance of the markings did not match initial expectations or the excellent installation results. Overall durability was poor. One project was restriped after the first winter and the other partially restriped after 2 years. The primary failure mode was adhesion loss with no significant areas of abrasion. The poor adhesion may have resulted from lower-than-desired temperatures of the material during application, caused by cooling effects of the atomizing air.

2. Conclusions

In summation, premature failure may relate primarily to the cooling effects of the atomizing air which resulted in the stripe being deposited on pavement considerably cooler than 450 F. Laboratory tests conducted by FHWA indicate that any significant drop in this application temperature would severely reduce adhesion to the pavement substrate. Effects of this reduced adhesion appear to have been magnified by variations in surface condition of the portland cement concrete pavement.

Information compiled from these projects permits the following findings:

1. The markings provided excellent initial appearance and reflectivity.

2. Epoflex consistently reached a completely hardened state in less than 30 sec, and was track-free in 10 sec or less.

3. Initial adhesion to both portland cement concrete and asphalt concrete pavements appeared excellent.

4. Application of the lines proceeded quickly and smoothly using the atomizing air-spray equipment built for these projects. Line quality was consistently good, with only minor adjustments required during striping to maintain satisfactory appearance, thickness, and production.

5. Overall durability was poor. One project required restriping after the first winter, while the other was partially restriped after 2 years and totally restriped after 3 years.

6. The primary failure mode was loss of adhesion, with no significant areas of abrasion failure noted. In areas of significant bond failure, the material generally had a soft, crumbly appearance and poor bead retention.

7. Some material remained in good condition with good reflectivity up to 2 or 3 years after installation.

8. Laboratory tests conducted by the material supplier and FHWA confirm that the material was properly formulated and not overheated during installation.

9. The most probably causative factor in the premature failure appears to be the cooling effect of the atomizing air which reduced adhesion of the epoflex to the pavement substrate. This may have been aggravated by variation in condition of the pavement substrate.

D. <u>Development of a Statewide Pavement Marking Policy</u> (4)

Research Report 143 (5) was a review of current pavement marking policy and existing pavement marking materials currently used. A revised pavement marking policy is outlined and several options are evaluated in terms of cost and performance. The ultimate goal is to provide cost-effective year-round markings on all state highways.

1. Abstract

This report describes development of a statewide pavement-marking policy by the New York State Department of Transportation. An overview of the Department's marking program under the previous policy is presented, including program scope, material costs, and marking durability. Shortcomings of the former policy are reviewed, and considerations for the new policy are discussed. Several options are outlined and evaluated in terms of costs and program effectiveness. The Department has set a goal of providing effective year-round markings on all state-maintained highways. To accomplish this, durable marking materials will be appliėd by contract on all expressways and high-volume urban arterials. Highway Maintenance Division forces will mark other highways with an improved chlorinated-rubber traffic paint. Several improvements in the program will result in better marking performance and reduced unit costs. The net result is expected to be a substantial improvement in the pavement-marking program with only a nominal cost increase.

2. Conclusions

After analysis and review of the options detailed here, the revised policy was drafted in final form for distribution throughout the Department. The policy statement defines the Department's pavement-marking program objective, and provides steps to its implementation. Actual details of the policy are listed, and organizational responsibilities are spelled out. Major elements of the policy are as follows:

1. Current resources and capabilities of the Highway Maintenance program are to be maintained.

2. The program will continue to use a combination of traffic paint and more durable materials for striping state highways. Material types are specified in the policy as discussed earlier in this report.

3. Durable marking materials will be installed and maintained by contract on limited-access highways and high-volume urban arterials (over 2500/lane ADT), and on remote highways when shown to be operationally cost-effective.

4. Traffic paint will be installed and maintained by Highway Maintenance on roads carrying less traffic.

5. Durable longitudinal markings will be included as part of capital projects on qualifying highways when the marking quantity exceeds 100,000 lin ft. However, they will no longer be included for smaller quantities, or on non-qualifying highways.

6. Initial paint striping on contracts not including durable markings will be installed by a combination of Highway Maintenance and contractor forces, depending on the quantity of striping and allowable time until its completion.

7. Special markings will continue to be included in most capital projects.

8. Annual region-wide durable pavement-marking contracts will be let to stripe or restripe qualifying highways.

9. The program will continue to include a combination of Maintenance and capital funds, approximately at current levels.

10. Responsibility for overall coordination of the program is assigned to the Traffic and Safety Division. Responsibilities of other program managers are also specified in the policy.

11. Efforts will continue to improve marking technology.

12. Each region is required to develop a regional pavement-marking plan, incorporating the criteria provided in the policy. This plan will identify the highways to be striped and restriped by contract-applied durable markings, and by paint applied by Highway Maintenance.

13. Each region is required to prepare an annual regional marking program detailing proposed contract and Maintenance marking activities for the coming year.

14. Although the policy is in keeping with the purpose of providing a systematic pavement-marking program, it recognizes that flexibility is required to handle operational needs and chnages in technology and funding.

E. Evaluation of Polyester Pavement Markings (5)

A total of four projects including 14 sites were evaluated in this study. These projects were located in Regions 3 and 4 on asphalt pavement surfaces only, including various traffic volumes. This report summarizes results of performance surveys in terms of durability, appearance, and reflectivity.

1. Abstract

This report describes performance of about 240 miles of white and yellow polyester pavement markings. Four projects were evaluated to determine in-service performance. Markings were installed on low-volume roadways, on existing asphalt concrete surfaces over worn paint lines, and on new asphalt surfaces at least a month old.

Most projects were in good to fair condition after 2½ years on low-volume roads (with AADTs less than 4000).

2. Conclusion

Polyester markings in this evaluation were placed over worn-out lines on existing asphalt pavement or on new asphalt at least a month old. None were placed on concrete. Asphalt roadways in this study had two-way AADTs ranging from about 12,000 to less than 1,000 vehicles. Snow-and-ice control involved sodium and calcium chloride de-icers, but sand and other harsh abrasives were not used.

Twelve of the 14 sites provided adequate service for 2½ years in terms of durability, daytime appearance, and reflectivity. Two sites required restriping after 1½ years. Based on overall performance, findings were as follows:

1. The results indicate that effective pavement markings lasting 2½ years on low-volume roads (AADTs less than 4000) can be obtained using polyester pavement markings.

2. Polyester lines experienced long no-track times, averaging 10 to 30 minutes, possibly requiring coning to increase line protection and minimize wet-line tracking by traffic.

3. Most sites were in fair to good condition. Even where stripes exhibited some failure and/or discoloration, they still provided acceptable daytime delineation.

4. Most sites provided fair reflectivity and about one-third provided good reflectivity. Lower brightness readings were mostly on yellow centerlines.

5. Polyester can be applied on asphalt pavement surfaces only two weeks to a month old. Also, they can be placed over existing paint stripes and provide good service.

6. No apparent problems occurred during installation. The only disadvantage was an objectionable odor behind the striping truck.

III. SUMMARY

Early in the 1980s, the New York State Department of Transportation initiated a new pavement marking policy emphasizing provision of cost-effective year-round markings on all state highways, including more widespread use of durable marking materials on most interstates and high-volume urban arterials and expressways. The predominant durable marking for long lines (lane, center, and edge lines) is a two-component epoxy with some limited use of thermoplastic. Preformed tapes are used mostly for transverse markings (stop bars, crosswalks, symbols, and legends), especially in lighted urban areas where severe conditions require frequent replacement. Results with epoflex, which exhibited premature adhesion failure, were unfavorable. For lower-volume and secondary roadways, the Highway Maintenance Division still uses traffic paint for striping operations. Currently, an alkyd (3-minute dry) traffic paint is being used, replacing a chlorinated-rubber traffic paint that is no longer available.

New York State Department of Transportation normally uses 4-in. wide long lines (lane, center, and edge lines). In 1990, the Department adopted a policy to use 6-in. wide long lines on interstate ramps and mainlines to aid the older driver.

Results from the research conducted under this project contributed to these policy changes.

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