Pavement-Marking Materials: New York's Experience

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ABSTRACT

A wide range of striping materials is available for pavement-marking programs. The four basic systems--traffic paints, thermoplastics, preformed tapes, and field-reacted materials--are described as well as the various materials used in each system. Important material properties are discussed, including cost, durability, methods of installation and maintenance, visibility, and handling safety. New York State's pavement-marking policies are described. Information on striping costs, material use, and results of durability studies is provided based on experience in New York with most currently available marking materials.

Pavement markings are installed on the roadway to provide guidance and regulatory and warning information to drivers. Lane markings have been used on New York highways since the 1930s. The safety benefits are readily apparent to motorists and have been documented on a nationwide basis (1). To provide the most effective markings at the lowest cost, transportation agencies continue to strive for improved marking materials, equipment, and programs. Comprehensive studies of marking shape, color, pattern, and reflectivity have led to established standards of practice at the state and national levels (2-4). However, implementing and maintaining these standard objectives is highly dependent on the personnel and equipment used and especially on the properties of the marking material.

Important properties of such materials include durability, cost, method of installation and maintenance, handling and installation safety, and visibility. Other significant considerations affecting materials selection include available installation equipment, number of workers and their skills, available funding, highway lighting, traffic volume and character, pavement type and condition, weather and climate, and maintenance practices. Use of painted lines reflectorized with glass beads has emerged over the years as the standard marking treatment, but during the past decade numerous other materials have become available.

The New York State Department of Transportation (NYSDOT) continues to mark most of its highway system with traffic paint but also makes widespread use of more durable marking materials. Large-scale installations have been completed for virtually all the commercially available types of more durable markings, including several large marking contracts completed in 1983. It is now department policy to install durable markings with nearly all highway contracts involving new or overlaid pavement. In addition, a substantial number of maintenance marking contracts for existing pavements have been completed or are planned. The choice of pavement-marking materials now available, including advantages, disadvantages, and price, is described. New York's pavement-marking policy and experience with durable markings over the past several years are summarized. This information is intended to provide background to other traffic and maintenance engineers to assist them in the choice of marking materials for their programs. (New York has also had experience with raised and recessed pavement markers. However, because of space limitations, this method of delineation is not discussed in this paper.)

MARKING SYSTEMS

Pavement-marking materials consist of a blend of several components, including resins and modifiers, pigments, and fillers. Some marking materials also include solvents, and virtually all include glass beads to make the stripe retroreflective. The type and amount of each component affect the characteristics of the resulting marking material. So far, no single material has emerged as best for every situation, but several good choices are available and capable of providing cost-effective, durable markings for virtually any situation.

Marking materials can be classified both by resin type and by application process. Because several of the common resin families are used in different types of markings, classification by resin type alone does not uniquely describe the entire range of materials available. For this paper, marking materials will be classified primarily according to application process, with subcategories for the various resin types.

Currently, the four materials and the basic processes in use for their application as pavement markings are as follows:

1. Traffic paints: All the components are carried in a solvent, and the paint remains liquid as long as it is sealed. Traffic paints are almost always applied by spraying, although brushes or rollers may occasionally be used. The solvent evaporates after application, and the resin forms a solid paint film.
2. Thermoplastics: The resins used in these markings have thermoplastic properties, melting at elevated temperatures and solidifying at ambient temperature. The molten material is applied to the pavement by extrusion or spraying and then cools to form a solid marking.
3. Preformed tapes: These markings are fabricated as roll or sheet stock in a factory or as cut-out legends. The preformed markings are installed by using either a preapplied adhesive on the marking or an adhesive applied to the pavement.
4. Field-reacted materials: Two or more components--a resin and a hardener--are mixed just before or during application to the pavement. A chemical reaction then occurs to form a solid resin. Application is by spraying, and mixing of the two components may be internal or external to the spray equipment.

PROPERTIES OF MARKING MATERIALS

A wide range of pavement markings is available in each of these groups, reflecting differences in both material composition and application processes. The various materials in each group are discussed next, and Tables 1 through 3 list advantages and disadvantages of each, costs, and durability information.

Traffic Paints

The longest in use, paints probably exceed all other materials combined in terms of roadway miles. Components include the paint binder and solvent as well as pigment and glass beads. Paints are generally applied at about a 15-mil wet-film thickness, drying to 8 to 10 mils depending on composition. Glass beads are usually dropped or sprayed on immediately after paint application at about 6 lb/gal, equivalent to about 2 lb/100 ft of 4-in. line. Premixed beads are occasionally also used. Traffic paint is distinguished from other materials by its solvent component. This makes it possible to pump, pour, and spray the material as desired, which then evaporates after spraying to form the solid line. Although the choice and amount of solvent affect drying time and thickness, the paint resin generally has the greatest effect on performance. Paints now in widespread use or under development include a number of resins, the following four being the most common:

1. Alkyd or modified-alkyd paints are generally the cheapest and fastest drying but the least durable of all markings. Durability can be improved by formula variations but usually at an increase in cost or drying time.
2. Chlorinated-rubber resins have produced the most durable traffic paints in New York's tests and appear to be the most cost-effective. However, these

TABLE 1 Advantages and Disadvantages of Pavement-Marking Materials

Material	Advantages	Disadvantages
TRAFFIC PAINTS		
Modified Alkyd	Lowest initial cost Good dry-night visibility Well established technology One-component Short dry times available Relatively safe handling Good equipment availability	Shortest life Poor wet-night visibility Year-round delineation not always possible Consumes petroleum distillate, contributes to air pollution
Chlorinated Rubber	Low initial cost Good dry-night visibility Well established technology One-component Relatively safe handling Good equipment availability Better durability than alkyd	Poor wet-night visibility Year-round delineation not always possible Consumes petroleum distillate, contributes to air pollution Strong-smelling MEK solvent Long dry times (3 minutes at best)
Latex (water-based)	Low initial cost Good dry-night visibility One-component Safe handling Good equipment availability Does not use petroleum distillate solvent	Poor wet-night visibility Year-round delineation not always possible Limited field experience Limited supplier competition Susceptible to rain damage during curing
Epoxy	Most durable paint Good dry-night visibility Relatively safe handling Good equipment availability Moderate initial cost External mixing ensures proper proportions	Limited field experience Uses strong-smelling MEK solvent Long dry time (2 minutes at best) Consumes petroleum distillate, contributes to air pollution
THERMOPLASTICS		
Alkyd and Hydrocarbon	Excellent durability Relatively safe materials Simple handcart may be used for installation Good night visibility Wet-night visibility better than paint	Higher cost than most materials Safety concerns (high installation temperature) Adheres poorly to concrete in northern climates Installation must be closely controlled
Epoflex	Moderate cost Generic formulation Can use existing thermoplastic spray equipment Fastest drying time (15 seconds) Can be applied at temperatures as low as freezing Good night visibility 100% solids (no evaporation loss) May provide good durability on both asphalt and concrete	Limited successful field experience High installation temperature Drop-on bead timing critical
PREFORMED TAPES		
Plastic	Excellent durability Installation requires little or no equipment No safety hazard (no heat or chemicals) Small areas easily repaired Inlaid installation provides good snowplow resistance	Highest first-cost Variable night visibility Late-season installations may not adhere well Limited supplier competition
Foil	Good durability Installation requires little or no equipment No safety hazard Small areas easily repaired Good dry-night visibility	High first-cost Late-season installations may not adhere well Performs poorly on coarse-textured pavement Limited supplier competition
FIELD-REACTED MATERIALS		
Epoxy	Excellent adhesion on both concrete and asphalt Good durability Excellent night visibility Can be applied on damp pavement Safe to handle 100% solids (no evaporation loss) Moderate first-cost	Specialized, expensive installation equipment Mixing and proportioning of two components critical, difficult to check Slow no-track (2 minutes at best)
Polyester	Good durability Low cost Installed with modified paint equipment Applies over existing paint Good supplier-contractor competition 100% solids (no evaporation loss)	MEKP hardener requires careful handling, special tanks and lines Poor adhesion to concrete Two-week cure required before striping new asphalt pavement Slowest cure time (10 to 15 minutes)

TABLE 2 Marking-Material Costs in New York State

Material	Approximate Material Cost[a]	Application Rate	Installed Cost, $/ft/4-in. line	
			Maintenance[b]	Contract[c]
TRAFFIC PAINTS				
Modified Alkyd	$3.50/gal	16 gal/mile (15-mil wet)	2.7¢	--
Chlorinated Rubber	$5.50/gal	16 gal/mile (15-mil wet)	4¢	--
Latex	$5.50/gal	16 gal/mile (15-mil wet)	4¢	--
Epoxy	$18/gal	16 gal/mile (15-mil wet)	8$	--
THERMOPLASTICS				
Alkyd	$850/ton	4500 ft/ton (125-mil)	---	--
Hydrocarbon	$750/ton	4500 ft/ton (125-mil)	---	32¢
Epoflex	$2500/ton	36,000 ft/ton (15-mil)	---	15¢-18¢
PREFORMED TAPES				
Plastic	80¢/ft	60-mil	---	$1.25
Foil (Durable Grade)	60¢/ft		---	--
FIELD-REACTED MATERIALS				
Epoxy	$30/gal	16 gal/mile (15-mil)	--	17¢-25¢
Polyester	$10/gal	16 gal/mile (15-mil)	---	7¢
GLASS BEADS	22¢/lb		--	
Installed on				
Traffic Paint		6 lb/gal (2 lb/100 ft)		
Thermoplastic (drop-on)		2 lb/100 ft (4-in. line)		
Field-Reacted Epoxy		25 lb/gal		
Field-Reacted Polyester		15 lb/gal		

[a]Based on supplier's estimates and actual New York State experience (1982-83).
[b]Actual or projected New York State costs (1982).
[c]Average or range of typical New York State contracts (1982-83).

formulas require long drying times and use a strong-smelling solvent, methyl ethyl ketone (MEK).

3. Epoxy paints use two-component epoxy mixed with a reaction-blocking solvent. In the presence of solvent, the mixture remains liquid for 7 to 10 days, but after spraying, the solvent evaporates and hardening occurs in 5 to 20 min. Durability is good, but experience is limited and the cost is high compared with that of other paints. The solvent is the same as that used in chlorinated-rubber formulas.

4. Synthetic-resin emulsions, also known as water-based or latex paints, have the appeal of easy cleanup, recycling of containers, and minimal environmental and safety hazards. Durability, drying time, and cost appear promising, but successful large-scale field experience is still limited.

TABLE 3 Expected Durability of Longitudinal Traffic Markings

Material	Expected Average Life, years[a]	
	Low Traffic[b]	High Traffic[c]
TRAFFIC PAINTS		
Alkyd	1/2	1/4
Chlorinated Rubber	1	1/2
Latex	2/3	1/3
Epoxy	2	1
THERMOPLASTICS		
Alkyd	7	4
Hydrocarbon	6	3
Epoxy	4	2
PREFORMED TAPE		
Plastic	8	4
Foil	3	1
FIELD-REACTED		
Epoxy	5	3
Polyester	4	2

[a]These figures represent typical life expectancies, based on New York State conditions, for markings installed outside wheelpaths. Service lives of individual markings may vary considerably, depending on actual project conditions.
[b]ADT of 1500 or less per lane per day.
[c]ADT of 1500 or more per lane per day.

Thermoplastics

These markings were developed in Britain during World War II because their alkyd resins, derived from alcohol, did not consume scarce solvents. Next to paint, thermoplastics probably enjoy the greatest popularity. The name derives from the resin's physical property of melting at elevated temperature. These materials include resin binder, pigments, calcium carbonate filler, and both premixed and drop-on beads. Typical application rates range from 20 to 125 mils, depending on resin type and application method. Drop-on surface beads are normally applied at about 2 lb/100 ft of line, equivalent to 6 lb/gal for 15-mil paint lines. The resin binder is a combination of several chemicals selected and blended to obtain a desired set of properties at the best price. Generally, resins have been either alkyds (derived from alcohol) or hydrocarbons (derived from petroleum); the choice is usually related to raw-material prices. Claims of superior durability have been made for alkyds, especially on concrete pavement, but considerable evidence exists that both can provide good service on asphalt pavement (5). Performance of both has been sporadic on concrete pavement, especially in northern states (6). Currently, hydrocarbon thermoplastic is somewhat less expensive than alkyd.

In 1980 a thermoplastic formulation was developed using a blend of epoxy resins (7). This material, known as epoflex, is claimed to adhere equally well to both asphalt and concrete pavement, but field experience is still limited.

Thermoplastics are installed by heating--usually to around 450°F--in a jacketed kettle and then applying the molten material to the pavement by either extrusion or spraying. Application equipment ranges from small hand-pushed carts to large automated truck-mounted rigs. Alkyd material is normally applied by extrusion, and New York specifies a thickness of 125 mils. Hydrocarbon material is most widely used in New York, normally extruded at 125 mils. Spray application of hydrocarbon material is also common, at thicknesses from 30 to 90 mils, but this technique has not had widespread use in New York. Epoflex is sprayed at 15 to 20 mils and dries rapidly, in about 15 sec.

Proper installation is critical to achieve good service. Material and pavement temperatures must be in the correct range to achieve good adhesion, and the equipment must be in good condition and operated properly. The higher cost of thermoplastics may be more than offset by their durability; up to 10 years is not uncommon under good conditions. On the other hand, lines in high-traffic areas may wear out in a year.

Preformed Tapes

Produced in a factory and shipped to the job site in rolls ready for application, marking tapes consist of a resin binder, pigment, glass beads, fillers, and an adhesive added to the back of the tape to provide adhesion to the pavement. A surface coat of glass beads is usually included to provide initial reflectivity, and paper backing may be added to protect the adhesive. Currently at least two competing brands of plastic tapes are available, supplied in 60- or 90-mil thicknesses using plastic resins. In addition, less durable tapes are available that have a single layer of pigmented binder and beads applied to a backing layer of metal foil. These foil-backed tapes range from temporary tapes with high initial brightness but low durability to products offering several years of service. In addition to the adhesive applied to the tape in the factory, a primer may be recommended in some cases to enhance pavement bond.

Preformed tapes are applied by two different methods. In the preferred inlaid method, they are placed on a new asphalt pavement while it is still warm and pressed partially into the surface by a paving roller. This method helps ensure good adhesion and may protect tape edges from snowplows and traffic. In the overlaid method used on existing pavements, the tape is laid out on the surface and tamped using a vehicle tire or roller. For large quantities of longitudinal stripes, an application machine is generally used to place and tamp the tape.

Preformed tapes have the highest initial cost of any marking material, which may be offset by excellent durability, especially abrasion resistance. For sites involving small quantities, particularly under severe conditions requiring frequent replacement, tapes offer a substantial advantage over less costly materials due to their ease of installation and repair, which require no equipment. Because reflectivity has been variable, with some tapes providing poor visibility for at least part of their lives, their use on dark rural highways is questionable.

Field-Reacted Materials

Separate-component materials require sophisticated equipment to ensure mixing in the proper ratios. Because the reaction begins as soon as the components mix, they must be stored and fed separately to the mixing point, usually at or beyond the spray nozzle. One or both components may be heated, typically to about 140°F, to decrease viscosity, improve pumping and handling, and possibly reduce setting times. Currently, two families of field-reacted markings are widely used--epoxies and polyesters. Both are normally applied at 15 mils, and because they contain no solvent, the hardened line retains 15 mils of binder and pigment plus the additional thickness of the drop-on beads. These materials offer good durability and excellent long-term reflectivity but at increased cost compared with that of traffic paints and longer drying times.

The first successful field-reacted epoxy marking was developed jointly by the H.B. Fuller Company and the Minnesota Department of Transportation during the early 1970s (8). Currently several manufacturers supply similar materials. The two components are mixed at the spray nozzle; typical ratios range from 1:1 to 3:1. Drying times vary with the formulation used but typically require from 10 to 15 min for a complete set. Less-expensive, longer-drying formulas are available for pavements not open to traffic during striping. By applying a heavy dose of glass beads (25 lb/gal) no-track times are greatly reduced, to as little as 2 or 3 min, and excellent reflectivity is obtained.

For polyester marking materials, the mixing ratio is about 50:1, so they are mixed externally by means of separate spray nozzles that mix the material as it contacts the pavement. The catalyst, methyl ethyl ketone peroxide (MEKP), is an active oxidizing agent requiring special handling precautions. The separate spray system for this component requires chemical-resistant storage containers and supply lines.

Typical polyester formulas require 10 to 30 min to achieve no-track conditions, even with 12- to 18-lb/gal applications of glass beads. Thus, coning is often required to protect the line until it sets. Although not as durable as epoxy, the resulting line is very hard and provides good reflectivity. However, its cost is lower than that of epoxy, making it a very cost-effective alternative.

NEW YORK'S EXPERIENCE AND CURRENT POLICY

The State's Experience

Traffic paint continues to be the prevalent marking material for state highways in New York, but the use of more durable materials is growing rapidly. The standard marking material for restriping is a modified-alkyd traffic paint, but thermoplastic and epoxy markings and preformed tapes are used extensively. Limited use has also been made of epoflex and polyester.

Traffic Paints

NYSDOT operates a fleet of truck-mounted paint applicators for most highway striping on the state highway system. The current standard traffic paint is a modified alkyd with a nominal 1-min drying time, applied at 140°F. In 1982 a total of about 51,000 miles of longitudinal lines were placed on the state system plus a small quantity of transverse and special markings. The actual application rate was 14.6 gal/mile at about 13.7 mils, and beads were applied at an average rate of 5.9 lb/gal compared with the planned rates of 16 gal/mile and 6 lb/gal. Unit material costs were $3.37/gal and $3.49/gal of white and yellow, respectively, and beads were $0.22/lb. Total in-place costs for longitudinal lines were as follows:

Item	Cost (¢/ft of line)
Material (paint, beads, solvent)	1.3
Labor	1.2
Equipment	0.2
Total	2.7

Although this traffic paint provides low first cost, fast drying times, and good workability, durability leaves much to be desired. For most roads, painted markings cannot survive for an entire winter, and insufficient delineation is provided until lines can be repainted in the spring. Based on accelerated wear tests of several marking materials placed by NYSDOT in 1981, several chlorinated-rubber traffic paints appear to offer greatly improved durability. In late summer 1982, about 3,300 gal of New Jersey Type IV chlorinated-rubber paint, both white and yellow, were placed by an NYSDOT striping crew over a wide range of highway conditions. A total of 270 miles were striped, but average applied wet-film thickness was only 12.5 and 9.5 mils for white and yellow, respectively. In spite of the reduced application rate, durability appears considerably better than that of the standard paint. All the markings survived the winter, and several were still in good condition by midsummer. Some adjustments in procedures were necessary to accommodate the new material, especially the longer drying times, which ranged from 4 to 10 min. In addition, the stronger-smelling MEK solvent generated worker complaints, although safety considerations are nearly identical to those for the toluene solvent used in the standard paint.

Based on the availability of current equipment and funding levels, traffic paint will undoubtedly continue to be widely used in the immediate future. Because they provide good reflectivity and low first cost, traffic paints continue to offer a cost-effective choice for low- and moderate-volume roadways where durability is sufficient to last through the winter. Even with better-quality paints costing \$5 to \$6/gal, in-place costs are projected at only about \$0.04/ft.

Thermoplastics

New York now uses extensive quantities of thermoplastic markings, primarily on new asphalt pavements placed under contract. In 1982 about 2,100 miles were placed at an average contract cost of \$0.326/ft, using hydrocarbon material. From mid-1979, when durable markings were included in paving contracts, through early 1983, about 6,360 miles were let to contract.

During summer 1981, thermoplastic markings on 80 projects installed in 1979 and 1980 were surveyed to determine durability (9). Both longitudinal and transverse markings were inspected, and damage was rated as none, slight, moderate, and severe. Abrasion and bond failure as well as snowplow damage were noted. In addition, damage to the leading edge of skip lines was recorded. Based on these 80 projects, results were generally good. Some abrasion wear and plow damage were recorded, but the markings generally appeared to be providing good delineation. In 1982 a second survey covered 170 sites installed between 1979 and 1981. Most projects were again in good condition overall, but 23 percent had moderate damage and 11 percent had severe damage. Three forms of distress were found on these projects. Abrasion damage was most prevalent in areas of high traffic wear: on transverse markings and longitudinal markings near intersections and on the insides of curves. In a few places bond failure was found, where the material simply failed to adhere to the pavement. However, snowplow-related failure was most common. The leading edge of skip lines was frequently damaged, as were solid lines installed on the pavement crown or on the high side of the shoulder break. Results of the two surveys are summarized as follows (80 projects surveyed in 1981, 170 in 1982):

Type of Damage	No. of Projects 1981	1982
None	6	2
Slight	60	109
Moderate	14	40
Severe	0	19

In 1982 two large contracts were let to install 1,275,000 ft of epoflex markings on both asphalt and concrete pavements. Bid prices were \$0.15/ft and \$0.18/ft for the two contracts. Hydroblasting and sandblasting were used to remove curing compound from new concrete and existing paint lines, respectively.

The installation proceeded smoothly, and acceptable line quality with good initial reflectivity was readily achieved by the contractor with truck-mounted thermoplastic spray equipment. However, good line quality could be achieved only when the material was maintained near the 450°F specified temperature. Rapid drying times resulted, and the line was completely set within 15 sec. Unfortunately, durability has not been uniformly good. On one of the two projects, large areas of both bond and abrasion failure appeared during the winter, and by spring only about half the material remained in most areas. Only sections of that project on new concrete unopened to traffic remained undamaged by spring. On the second project, several large areas of failure also occurred during the winter, and by spring about 10 percent of the lines were lost, whereas the rest remained in good condition. By September 1983 about 15 percent of the total project required restriping, although the rest was still serviceable. FHWA is currently reviewing the performance of this material, but no definite causes of the failure have been identified. Further work with epoflex is not planned at this time.

Preformed Tapes

Preformed tapes have been in use by NYSDOT since the early 1970s; widespread installations have been made for urban intersections and other special situations. Several applications for longitudinal lines were also made in the late 1970s. A recent research report described the performance of a large number of those projects (10), including a wide range of materials and roadway conditions. Although some installations experienced early failures, most performed well. Poor adhesion was observed at several sites but was frequently related to either late-season installations or poor pavement conditions (dirt or old pavement markings). Minor snowplow chipping was common but was normally confined to small areas on the leading edge of transverse markings or along the edges of longitudinal markings. Several instances of accelerated abrasion wear and bond failure were noted in areas of poor pavement condition where traffic and snowplow forces were concentrated on small portions of the tape. Good adhesion was obtained with both inlaid and overlaid installations, but adhesion failures were more prevalent with the overlaid method.

Both total traffic volume and marking location relative to the wheelpaths affected marking life. Estimated services lives ranged from as short as 1 year in the wheelpaths of high-volume roadways to considerably more than 5 years outside the wheelpaths on low-volume roads. In 1981 a large installation of plastic tape was placed on new tine-textured concrete pavement on a rural interstate; two brands of material were used. One product is performing well and is expected to provide several years of service, but the other experienced extensive bond failure during the first winter, limiting its service life to less than 1 year.

In spite of good abrasion resistance, retroreflectivity was not consistently good. The original surface bead coat provided excellent night visibility, but these beads gradually wore away after a few weeks to several years, depending on traffic and snowplow wear. After the surface beads were lost, the tape had a period of low reflectivity, which gradually improved as more matrix beads became exposed. In urban areas with overhead lighting, night visibility was generally considered adequate. However, on dark rural roadways with higher travel speeds, plastic tapes did not provide consistently acceptable delineation. Durable grades of foil tapes provided brighter and more uniform performance, but it appeared that bead degradation may limit tape life to about 3 years.

Plastic tapes are much more expensive than other markings. Contract prices averaged $1.25/ft installed for 165,000 ft of material placed in New York in 1982. Current purchase price for the tape is about $0.80/ft of 4-in. line for plastic and about $0.60/ft for durable-grade foil. This high cost, combined with poor reflectivity, has limited tape use primarily to small installations such as intersections and urban markings and other areas where small quantities provide an advantage for tape because installation is simpler than for other materials.

Field-Reacted Materials

In 1978, 100,000 ft of two-component epoxy markings were installed on several pavements near Albany. Some performed well and remain in service after 5 years, but others experienced bond failure during the first winter. This failure was attributed to a malfunction in the spray equipment, and an equivalent quantity of replacement markings was placed in 1979. Those subsequent markings all performed well; most remained serviceable and bright after 4 years (11). Based on this good experience, several large installations were completed over the next few years, primarily on interstate concrete pavements, all of which continue to provide excellent service. In 1982 epoxy markings were also placed on several new asphalt overlays, also generally with good results.

A total of nearly 600 miles of epoxy line have now been placed. Prices have varied widely with competition, contract quantity, and other factors. However, several large contracts have been awarded at $0.17/ft to $0.18/ft of 4-in. line, and smaller contracts at scattered locations have been awarded at about $0.25/ft.

The first polyester installation in New York included 20,000 ft of yellow on moderate- and high-volume asphalt pavements in Rochester. That material provided 2 years of service under heavy traffic. Based on favorable reports from other states, more work was initiated. In 1982 two counties placed nearly 100 miles of material on several county highways, and performance was good during the first winter. Early in 1983 a contract was awarded to place 130 miles of line on several central New York highways at a cost of $0.07/ft. Based on reports from other states and limited experience in New York, polyester does not adhere well on concrete pavement but appears to offer a cost-effective marking for low- to moderate-volume asphalt pavements.

The State's Current Policy

In 1979 New York adopted a policy calling for inclusion of durable pavement markings on contract work. Thermoplastic markings were specified for asphalt pavement based on favorable price and a good performance record. Preformed plastic tape was permitted on lighted highways where the retroreflectivity was not critical and where small quantities or special markings reduced the price differential compared with thermoplastic. Tapes were also allowed on concrete pavement but only in limited quantities because of their high cost and the lack of experience on tine-textured surfaces.

In 1983 this policy was revised to reflect advances in marking technology. Thermoplastic continues to be the designated marking for most asphalt pavement; two-component epoxy is designated for concrete. Preformed plastic tape may be substituted where small quantities reduce price differentials and for high-volume intersection work. On projects with both asphalt and concrete pavements, two-component epoxy may be used on both pavement types.

Under this policy, durable markings are now included on all contract work where pavement conditions are suitable. However, in cases where they are not suitable, such as those in need of overlay, painted markings are applied by maintenance forces. In addition to including durable markings in highway construction and reconstruction contracts, NYSDOT is making wider use of pavement-marking contracts to install durable materials on highways where painted markings cannot provide good year-round delineation. Several contracts were let in 1983 to install several hundred miles of markings at locations around the state. These include interstate highways and high-volume roadways as well as remote highways where repainting causes scheduling difficulties.

New York is now committed to providing effective year-round delineation on all state highways and to accomplishing this in the most cost-effective manner possible. Research and development engineers will continue to stay abreast of new developments in pavement-marking technology, and promising new materials will be implemented whenever they can provide improved performance or lower cost. Given the wide range of materials available, New York's marking program will continue to use a variety of materials, including traffic paints as well as more durable materials.

SUMMARY

A wide range of marking materials is now available for pavement-marking programs, ranging in durability from a few months to several years. Four basic categories of marking systems include traffic paints, thermoplastics, field-reacted materials, and preformed tapes. Several material types are available in each category; costs range from less than $0.03/ft to more than $1/ft in place.

Important properties of these materials, including cost, durability, methods of installation and maintenance, visibility, and handling safety, are

TABLE 4 Summary of Marking Materials

	Property				
Material	Durability	Cost	Ease of Installation	Installation Safety	Night Visibility
Paints	Low	Low	Variable	Variable	Good
Thermoplastics	Good	Moderate	Difficult	High-Temperature	Fair-Good
Tapes	Excellent	High	Easy	Good	Poor-Good
Field-Reacted	Fair-Good	Low-Moderate	Difficult	Variable	Excellent

summarized in Table 4. Considering the characteristics and demands of a particular highway and properties of available materials, pavement markings can be selected to provide cost-effective, year-round roadway delineation. NYSDOT makes widespread use of several material types and has had limited experience with several others. Its marking program currently relies primarily on modified-alkyd traffic paint, with extensive use of thermoplastic and two-component epoxy included in construction and striping contracts. Preformed tapes are used in limited quantities for intersection markings and other special situations. Limited use has been made of chlorinated-rubber traffic paint, epoxy thermoplastic, and two-component polyester markings. The department has a policy of maintaining effective year-round markings on all state highways. To accomplish this in the most cost-effective manner, continued use of a variety of materials combined with continuing research and development activities is expected.

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