



Traffic Engineering and Parking Divisions

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June 22, 2010

TO: Pedestrian/Bicycle/Motor Vehicle Commission
FROM: David C. Dryer, P.E. City Traffic Engineer
SUBJECT: **Pavement Markings**

The Pedestrian/Bicycle/Motor Vehicle Commission has requested information and data pertaining to the use and selection of pavement marking material. To provide some background information relevant to the discussion, I have provided a previous memo prepared for Alder Bruer and the Mayor's Office, dated October 26, 2009.

This memo should provide the information requested by the Commission and staff will be available to answer any questions.



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October 26, 2009

To: Alderperson Tim Bruer; cc: Joel Plant

From: David C. Dryer, P.E., City Traffic Engineer

Subject: Pavement Markings and Budget Considerations

Introduction

At the October 13, 2009 Board of Estimates meeting, you requested that Traffic Engineering staff prepare a short memo describing pavement markings and their application used on Madison Streets. I have also provided their associated costs and project examples to help illustrate the discussion. This memo should provide useful information when considering pavement markings and funding in the City of Madison.

Overall Message

- ❑ Street mileage in the City has grown significantly in the last ten years--the budget, resources, and personnel for markings have not. For example, it has been over ten years since the City has added the required 2-person crew and truck to allow the TE Division to keep up with the growth in street mileage and markings and signing. As such there has developed a backlog of streets needing new markings which staff is actively attempting to reduce.
- ❑ At the same time that street mileage has increased, the number of new types of markings for bicycle lanes and crosswalks has also increased, essentially doubling the amount of new markings required for those same streets. The Council's adoption of the Platinum Bicycle Report has added more earnest and priority to ensuring streets get bike lanes, bike boxes and more included.
- ❑ In addition, as the City has added more funds to street resurfacings and reconstructions, the need and demand for new markings has also increased considerably. Patches and spot resurfacings has also increased leaving gaps in an otherwise well-marked street.
- ❑ The City uses two primary marking materials): 1) epoxy; and 2) paint. Paint in Madison's winter climate requires remarking every year. Epoxy material requires remarking about every 3 years. The epoxy markings are done under a private contract. Paint and other special markings and materials are done by TE personnel. Other special markings are required for City streets, which are done by TE personnel.
- ❑ To help with demands, the City has moved to adding more money towards epoxy markings due to their longer lasting wear and because their life cycle costs are lower. The City has expended about \$90,000 per year on a maintenance epoxy contract.
- ❑ As street mileage and special interests for bicycles and pedestrians increase there will continue to be a need to increase funds and personnel for both epoxy and paint markings, and other special markings.

Overall Recommendation

If the community is interested in keeping pace with the growth in street mileage and special interests of bicycles and pedestrians for pavement markings, staff recommend: 1) additional resources for the epoxy markings program; and 2) consideration of adding the required 2-person crew and truck to address the lack in adding new marking and signing personnel and truck over the last ten years and keep pace with the increased workload for painting and other special materials related to bicycling and walking.

Background Information / Discussion

Pavement markings are an important component of the street system, and a very important part of the communication system for road users. Pavement markings help street users correctly position their vehicle, they help pedestrians identify where street crossings should be made and where motorists must yield, they help define space where people should bicycle and where motorists should share the road. Markings help guide motorists through the many different situations they encounter and warn of upcoming conditions.

In many cases, pavement markings supplement and enhance the messages of other traffic control devices such as traffic signs and signals. Sometimes pavement markings are the only effective way of providing positive guidance or communicating certain regulations or other messages. Markings communicate their messages to the street user through a uniform system of colors, patterns, widths, symbols, and words. Uniformity of these features throughout the Nation are required by Federal law and makes it possible for people to instantly recognize the meaning of the markings in any given situation and location.

Many materials can be used for pavement markings. However, the performance and cost of the different materials vary greatly. It is also important to recognize that some materials are more appropriate for a given set of circumstances than other materials. The useful life of a pavement marking material often varies widely based on many factors. Materials are selected that will meet or exceed the performance requirements at the lowest cost. To maximize cost-effectiveness, material selection is based on roadway surface type, traffic volumes, and expected remaining service life of the pavement.

Year-round climatic conditions also affect the long-term performance of a pavement marking material. Madison receives heavy snowfall and therefore its markings are frequently exposed to heavy abrasion due to snowplow, sanding, and chemical activity.

In Madison four types of pavement marking materials are used, see Table 1. Each material has unique benefits and disadvantages which determine in which application the material will be used.

Table 1:

Material	Normal Life	Visibility	Reflectivity	Application	Availability	Special notes
<u>Paint (Latex)</u>	1 year or less	Low 3-4 mils	Low (Medium w/ glass beads)	Paint or spray Applies on All Road Surfaces—Old/New Asphalt & Old/New Concrete	High	Does not last long and has low visibility, reflectivity. Not the best option for med-high traffic, especially curves
<u>Epoxy</u> (2 Part-Paint- and liquid transport/binder)	3-5 yrs.	Medium 15 mils	Medium (Varies w/ low, medium, high index beads)	Applied via spray Applies on All Road Surfaces—Old/New Asphalt & Old/New Concrete	Via Contractor only- (Brickline, Century Fence, Mega Rental) Any Epoxy Contractor that is qualified by the City of Madison can bid engineering projects	Visibility and reflectivity can be increased with standard glass beads, visibead and high index airport beads. Need to work within contractors schedule.
<u>Cold Laid Material, a.k.a.Sta-mark</u> (Preformed Plastic, Pliable Polymer)	5-10 years Longer If inlaid w/ paving process— lasts life of pavement	Medium-High 40-50 mils	Medium-High (Varies w/ low, medium, high index beads)	Preformed plastic glued down Applies on All Road Surfaces—Old/New Asphalt & Old/New Concrete	City can install limited amounts of Sta-mark, large projects require contractors	More visible at night than epoxy. Stays whiter than epoxy. Better in wet weather than epoxy. Contains beads encased within materials.
<u>Thermoplastic</u> (Melted, Molten Material)	4-8 yrs.	High 90 mils	High (Varies w/ low, medium, high index beads)	Special Equipment Needed Best Applied on New Asphalt—Not Good Old Asphalt & Old/New Concrete	No private contractors in WI install this product. The City installs this on public streets only.	Much more visible than Sta-mark; Material stands above the pavement so it has high visibility and reflectivity.

MATERIAL DISCUSSION

Paint (Water based/Latex)

Traffic paints are the oldest and most widely used pavement marking materials in existence. Paint is the most common pavement marking material used by TE. Paint still remains the most inexpensive of all pavement marking materials. Paint is currently the only long line material applied by City forces on large scale remarking projects. Long line application generally requires the use of a large center liner pavement marking truck with high capacity tanks and compressors while crosswalks and stop bars generally are marked with smaller push type curb sprayers.

Epoxy

Two-component epoxy-resin paints were first introduced in the 1970s and have since developed into a common pavement marking material used by many agencies throughout the US. Epoxy materials are durable, sprayable materials that provide exceptional adhesion to both bituminous surfaces and concrete surfaces with good abrasion resistance. Epoxies are more expensive than standard paints and are about the same cost or slightly more expensive than most thermoplastics.

Epoxy pavement markings are durable and recognized for exceptional durability on asphalt and concrete surfaces alike. This is a result of tight bonding to the pavement surface that results from the chemical reaction that occurs when the two components are mixed. Research has shown that epoxy paints are generally less sensitive to application factors than thermoplastic materials, allowing epoxy to have exceptional durability under many different roadway conditions. Epoxies can be applied at much lower surface temperatures than the other materials and is less sensitive to pavement moisture. On low-mid-

volume roadways, epoxies have been known to provide service lives in excess of four years.

One drawback associated with epoxies is that they often take longer to dry than other materials. Epoxies also cannot be placed over markings made from other materials, limiting their use as a restripe material. Because of the nature of the two-part system of epoxy, expensive machinery is required for application. This equipment is beyond the City's capabilities and therefore, epoxy is only applied by contractors. Epoxy is used on both bituminous and concrete streets, and while it is more expensive than latex paint, its longer life and lower lifecycle cost makes it a superior product.

Preformed Tapes, i.e. Sta-Mark

Preformed tapes are cold-applied, preformed, pavement marking materials that are supplied in continuous rolls of various lengths and widths. Preformed tapes have the advantage over sprayed or extruded materials because they do not require expensive application equipment and can be done by less experienced operators and they require no drying or curing times--beyond the glue. While tapes have a significantly higher initial cost than most other materials, the service lives are usually superior to most other materials including thermoplastics, often making them a cost-effective choice in locations with high traffic volumes. Preformed tapes are used for transverse markings and/or longitudinal lines in high-traffic areas. Tapes are highly durable and abrasion resistant in most applications. Because of their high installation costs and slow application procedure, they are often used only in locations with the most severe traffic conditions that require frequent replacement of standard pavement markings.

Preformed plastic tapes generally have good durability and abrasion resistance. Inlaid tapes almost always outperform overlaid tapes. Inlaid tape is placed in a "slot" in the pavement which protects the tape edge from the blade tip of snowplows, because of the required slot grinding costs are greatly increased. Tapes are known to distort in areas that have a high amount of turning movements or weaving over the markings. A clean surface is more important for tapes than for any other material, therefore tapes must be applied in areas where good bonding can be ensured. When applied properly tapes can provide durability and visibility for many years.

Thermoplastic Markings

Thermoplastics have been used as a pavement marking material in the United States since the late 1950s. Thermoplastic is so named because the mixture of plasticizer and resins that serves to hold all of the other ingredients together exists as a solid at room temperature but becomes liquid when heated. Thermoplastics are installed at extremely high temperatures, with suitable application temperatures ranging from 400-450°F, with 420°F as the recommended temperature for most applications. Because of the high temperatures, only experienced crews are permitted to apply thermoplastic.

The popularity of thermoplastic markings can be attributed to several factors including:

- readiness for immediate use
- high durability
- good retroreflectivity
- relatively low cost.

When properly formulated for a given roadway surface and correctly applied, thermoplastic markings have been known to last from 4 to 8 years depending on traffic volumes.

Durable pavement markings, such as thermoplastic are desirable on high-traffic-volume roadways because they require fewer restripe cycles, reducing the amount of worker exposure and delay to street users. However, on very low-volume roads, paint can provide comparable performance to durable materials at a much lower cost.

Thermoplastic materials provide suitable performance for a broad range of traffic volumes. Because thermoplastic dries very quickly, it is well suited for higher traffic volume roadways. However, thermoplastics may not be the most durable marking in areas where very high-traffic volumes or where heavy traffic and weaving result in increased wear due to tires. Permanent tapes may provide better durability under extreme traffic conditions, for example the material used on the recent reconstruction of East Washington Avenue.

COST DISCUSSION

The cost per unit of 4 inch line is shown in Table 2 below.

Table 2:

Material	Normal Life	Availability	Cost ^[1]
<u>Paint (Latex)</u>	1 year or less	High	15¢/lin., ft. for 4" line (cheapest initial cost, but highest life cycle cost)
<u>Epoxy</u> (2 Part-Paint-and liquid transport/binder)	3-5 yrs.	Current Contractor- Brickline (Brickline, Century Fence, Mega Rental) Any Epoxy Contractor that is qualified by the City of Madison can bid engineering projects	32¢/lin., ft. for 4" line (Brickline) Price may vary/ with engineering projects
<u>Cold Laid Material, a.k.a.Stamark</u> (Preformed Plastic, Pliable Polymer)	5-10 years Longer If inlaid w/paving process— lasts life of pavement	Three contractors other than City: Brickline, Century Fence, Mega Rentals	\$3.75/lin. ft. for 4" line
<u>Thermoplastic</u> (Melted, Molten Material)	4-8 yrs.	No private contractors in WI install this product. The City installs this on public streets only.	74¢/lin., ft. for 4" line

Source: Madison TE Division

[1] Costs are estimates. Prices may vary depending upon location, type of marking line and quantities required. Price for Bike Lane Arrow/Symbol is \$140.00 per set (for Brickline's current maintenance contract); it may vary with other projects.

PROJECT COSTING EXAMPLES

Midvale Blvd:

2-LANE EACH DIRECTION MEDIAN SEPARATED ARTERIAL WITH PARKING
SINGLE BARRIER LINE BIKE LANE

Table 3:

	PRIMARY	PRIMARY	SECONDARY	SECONDARY
	EPOXY	PAINT	THERMOPLASTIC	STA-MARK
TOTAL COST PER MILE	\$14,389.87	\$5,513.80	\$21,861.73	\$59,443.33
CROSSWALK COST PER MILE	\$8,366.67	\$2,041.00	\$9,516.67	\$8,366.67
NON BICYCLE COSTS PER MILE	\$2,816.53	\$1,591.47	\$4,443.47	\$18,153.33
BICYCLE MARKINGS COST PER MILE	\$3,206.67	\$1,881.33	\$7,901.60	\$32,923.33
LIFE CYCLE	4 YEARS	1 YEAR	5 YEARS	10 YEARS
LIFE CYCLE COST PER YEAR	\$3,597.47	\$5,513.80	\$4,372.35	\$5944.33

Fair Oaks Avenue:

1-LANE EACH DIRECTION UNDIVIDED 44' WIDE COLLECTOR WITH PARKING
DUAL BARRIER LINE BIKE LANE

Table 4:

	PRIMARY	PRIMARY	SECONDARY	SECONDARY
	EPOXY	PAINT	THERMOPLASTIC	STA-MARK
TOTAL COST PER MILE	\$13,887.62	\$5,744.57	\$23,197.71	\$69,842.86
CROSSWALK COST PER MILE	\$7,066.67	\$1,574.86	\$8,076.19	\$7,066.67
NON BICYCLE COSTS PER MILE	\$2,094.10	\$1,215.43	\$2,713.52	\$11,076.19
BICYCLE MARKINGS COST PER MILE	\$4,726.86	\$2,954.28	\$12,408.00	\$51,700.00
LIFE CYCLE	4 YEARS	1 YEAR	5 YEARS	10 YEARS
LIFE CYCLE COST PER YEAR	\$3,471.90	\$5,744.57	\$4,639.54	\$6984.29

NOTES: Life cycle length can vary significantly with asphalt quality, traffic volume, salt routes and amount of snowfall. The Life Cycle value selected for these examples was based on expected life given field staff experience.

Epoxy cannot be installed over existing paint markings. Existing paint must first be ground off, substantially raising the price of installation.

Thermoplastic can only be installed on a newly installed asphalt surface. Thermoplastic cannot be installed on a concrete roadway. Thermoplastic would require excessive amounts of staff time to complete projects of this magnitude.

Sta-mark life cycle is greatly increased when ground in with new pavement installation. Much of the markings may last for the life of the pavement. Prices and life cycle shown are for ground in Sta-mark (Note Life Cycle may be longer than shown).



City of Madison Pavement Marking Options - 2009

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¹ Costs are estimates. Prices may vary depending upon location, type of marking line and quantities required.
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Table 6
Theoretical Selection Matrix

Pavement Type	First Choice	Second Choice	Third Choice
Concrete	Epoxy / ground in Sta-mark	Paint	
New Blacktop Asphalt Pavement	Epoxy	Thermo	Paint
Old Blacktop Asphalt Pavement	Epoxy	Paint	

* Material selected is a function of pavement type, project type, funding availability, FAWA approvals, street functional class, traffic volume, pavement life expectancy, etc.