The Ohio Department of Transportation
Office of Research & Development
Executive Summary Report

Long Term Striping Alternatives for Bridge Decks

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Problem Statement

ODOT uses a number of pavement marking materials including waterborne and alkyd traffic paint, polyester, thermoplastic, preformed tapes, epoxy, and heat-fused preformed thermoplastic; which are addressed in ODOT Construction and Material Specifications (C&MS) Items 640 and 740. Material selection is presented in Table 397-1 of the 2002 Traffic Engineering Manual (TEM), whereby the material type is chosen according to the remaining life of the pavement surface, type of line (longitudinal line or auxiliary), type of pavement surface (asphalt or concrete), and average daily traffic (ADT). According to this table, durable markings such as thermoplastic and epoxy are more likely to be applied on highways with high traffic volumes and pavements with a remaining surface life in excess of four years, while non-durable markings such as traffic paint and polyester are recommended for restriping. Furthermore, thermoplastic markings are specified for new asphalt pavements and epoxy markings are specified for new concrete pavements. This constraint, however, has significant financial impacts on projects that include concrete bridge decks connected to mainline asphalt pavements. The additional cost in such projects is resulted from paying the contractor an extra cost to use thermoplastic for the asphalt portion and epoxy for the concrete portion, or from dividing the project into two separate projects; one for the asphalt and another for the concrete.

Due to these financial concerns, thermoplastic, which has poor durability on concrete surfaces, is currently being applied onto the concrete bridge decks as well as the mainline asphalt pavements. This often results in premature debonding in the bridge stripes compared to those on the adjoining asphalt pavement.

This deficiency raises major safety concerns regarding these bridges, and leads to low performance ratings as measured using various performance indicators in force by ODOT.

As a result, ODOT invited the pavement marking industry to provide alternative marking materials and/or installation techniques to be tested on Portland cement concrete bridge decks along interstate I-71 in District 3; and initiated this project to evaluate the performance of the proposed materials.

Objectives

The objectives of this project are:

1. Develop a comprehensive performance evaluation plan for pavement markings;
2. Evaluate the performance of different marking materials on Portland cement concrete bridge decks using qualitative as well as quantitative measures;
3. Compare the performance of these materials based on durability, daytime color, and nighttime visibility;
4. Augment the performance evaluation results with data from the National Transportation Product Evaluation Program (NTPEP);
5. Compare these materials based on cost-effectiveness; and
6. Recommend changes to current ODOT practices and specifications to address the research findings.

Project Description

The performance of several pavement marking materials, including waterborne traffic paint (Ennis fast dry waterborne traffic paint), thermoplastic (Swarcotherm alkyd), preformed thermoplastic (Premark Plus and Premark Contrast), slow cure epoxy (HPS-2, Mark 55.2, and LS 60), fast cure epoxy (Mark 55.4 and LS 70), polyurea (HPS-5, Mark 75, Glomarc 90), modified urethane (HPS-4), methyl methacrylate (Duraset 1 and Duraset Pathfinder), and high performance durable tapes (3M 380WR ES, 3M 380WR-5 ES, and 3M 270 ES), was evaluated on sixteen Portland cement concrete bridge decks, connected to mainline asphalt pavement. The bridge decks are located in Ashland and Richland counties in ODOT District 3 along interstate I-71 in a location where the interstate has three lanes per direction, with an average daily traffic (ADT) of about 42,000 vehicles per day.

Each material was installed in four locations along the three lanes of the interstate. Yellow was installed on the left edge line and white was installed on the two lane lines and the right edge line. All materials were installed in 150-mil (3.8 mm) grooves. The groove depth selected was the same as the transverse tines depth on the bridge decks in order to ensure that all traces of the old thermoplastic have been completely removed; and thus, eliminate its effect on the newly installed products.

The performance evaluation period lasted for slightly over two years. The performance evaluation plan included measuring retroreflectivity using two handheld LTL-X retroreflectometers and color using a MiniScan XE Plus colorimeter. It also included rating daytime color, nighttime visibility, and durability according to Supplemental 1047 (dated April 18, 2008). In addition, a pocket magnifier was used to examine glass bead retention as it varied over time.

The performance evaluation results obtained during the periodic evaluations were compared to preselected milestone performance criteria and augmented with NTPEP data from the Pennsylvania and Wisconsin test decks. The service life of each marking material was predicted using different mathematical models that estimated the time required for retroreflectivity to drop to a threshold value of 150 mcd/m^2/lux for white markings and 100

mcd/m^2/lux for yellow markings. The service life predictions were then used to calculate the life cycle costs of the marking materials in order to determine their cost effectiveness.

Conclusions & Recommendations

Based on the performance evaluation results and the subsequent analysis findings, the following conclusions and recommendations were made:

- Three slow cure epoxies were evaluated in this study, namely IPS HPS-2, PolyCarb Mark 55.2, and Epoplex LS 60. All three products performed satisfactorily over the two-year performance evaluation period, with an expected service life of about 3 to 5 years. From among these products, only LS 60 is currently included in ODOT "Approved List" of pavement markings. Hence, it is recommended to add both HPS-2 and Mark 55.2 to this list.
- Two pavement marking materials showed the potential of lasting for more than five years under high traffic, namely IPS HPS-5 polyurea and Epoplex Glomarc 90 polyurea. These products, however, did not compare favorably with the less expensive slow cure epoxies based on the life cycle cost analysis results. Therefore, it will not be cost effective to use them on a large scale. Another concern regarding Glomarc 90 is that Epoplex has recently changed the bead systems used in this product. Therefore, additional evaluation may be necessary for this material with the new bead systems. Still, it is recommended to include HPS-5 polyurea in ODOT "Approved List" on a conditional basis by limiting its use to a number of projects per year that involve Portland cement concrete surfaces subjected to high traffic.
- The third polyurea product PolyCarb Mark 75 did not perform as satisfactorily as the other two polyurea products. Therefore, it is not recommended to include this material in ODOT "Approved List."
- Given their very high initial cost, durable tapes did not seem to offer clear advantage over the less expensive slow cure epoxies under dry conditions. One of the durable tapes, 3M 380WR ES series, contains specially designed optics to improve its performance under wet night conditions. Additional research is needed to evaluate the performance of this tape under such conditions.
- The performance of HPS-4 modified urethane was comparable to that of slow cure epoxies. This material is slightly more expensive. Yet, it dries much faster, which makes it desirable for areas with high traffic volumes since it requires less traffic control. Therefore, it is recommended to conditionally approve this material.
- Epoplex LS 70 slow cure epoxy failed due to durability in less than eight months. Therefore, it is not recommended to approve using this material.
- Even though PolyCarb Mark 55.4 fast cure epoxy is currently included in ODOT "Approved List," this product had one of the highest retroreflectivity deterioration rates. Therefore, it is recommended to review recent projects striped with this material to determine whether to keep it or remove it from the "Approved List."
- The performance of the preformed thermoplastic Premark Plus and Premark Contrast was comparable to the performance of the less expensive slow cure epoxies over the two-year performance evaluation period. Therefore, it is not recommended to use these materials for longitudinal applications on Portland cement concrete bridge decks.
- Poor installation of Duraset 1 methyl methacrylate resulted in poor performance. Additional evaluation may be required to assess the performance of this material. At the present, it is not recommended to include it in ODOT "Approved List".
- The performance of Duraset Pathfinder methyl methacrylate was comparable to that of the less expensive slow cure epoxies. Therefore, it is

not recommended to include it in ODOT "Approved List."
- Interestingly, even though Ennis fast dry waterborne traffic paint did not meet most milestone retroreflectivity criteria set forth for the more durable products, its performance was reasonably acceptable (retroreflectivity is greater than 150 mcd/m^2/lux for white markings and 100 mcd/m^2/lux for yellow markings) even after two years from installation. This material is typically applied on the surface rather than in groove. However, in this study, it was installed in 150-mil (3.8 mm) grooves similar to the rest of the materials. One disadvantage of doing so is that the lines became completely invisible under wet night conditions once the grooves were filled with water. This was not necessarily the case for thicker materials and materials that had patterned structures.
- Some of the evaluated materials such as HPS-2, HPS-4, Mark 55.2, and Mark 55.4 had acceptable yellow color even though their color readings were very close to the bottom corner of ODOT yellow color specification box. On the other hand, some of the evaluated materials had white color readings well within ODOT white color specification box, but did not have acceptable color contrast. This calls into question the applicability of ODOT color specifications to determine pavement marking daytime color acceptability.
- Finally, grooving has been shown to improve the performance of some of the pavement markings such as Ennis fast dry waterborne traffic paint. Therefore, it is recommended to consider this surface preparation technique in the installation of pavement markings on Portland cement concrete bridge decks that are subjected to high traffic.

Study Limitations

- All materials evaluated in this project were installed in 150-mil (3.8 mm) grooves. The performance of these materials will probably be different if they were applied on the surface.
- Pavement marking performance under dry conditions is not necessarily indicative of their performance under wet conditions. The 3M 380WR ES wet reflective durable tape, for example, is designed to improve retroreflectivity under wet conditions. However, this factor was not taken into consideration in this study. Therefore, additional research is needed to evaluate the performance of this tape under such conditions.
- The life cycle cost analysis procedure employed in this project did not address the impact of frequent striping using less durable pavement markings on traffic flow and the potential risk to maintenance crew. These factors must be taken into consideration in determining which pavement marking material type to use.

Implementation Potential

It is recommended to use the following products on Portland cement concrete bridge decks: Ennis fast dry waterborne traffic paint (for bridges with low to medium traffic volumes or as part of a mainline asphalt pavement striping project), LS 60, HPS-2, Mark 55.2, Mark 55.4, HPS-4, and HPS-5. Grooving has been shown to improve the performance of some of these materials such as Ennis fast dry waterborne traffic paint. Therefore, it is recommended to consider this surface preparation technique in the installation of pavement markings on Portland cement concrete bridge decks that are subjected to high traffic. To this end, it is recommended to add the following products to ODOT "Approved List" of pavement markings: IPS HPS-2, PolyCarb Mark 55.2, IPS HPS-4, and IPS HPS-5.