Pavement Marking Life Cycle Cost Analysis

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Overview

• NC pavement markings include paint, thermoplastic, cold applied plastic and polyurea.

• This research was coordinated by the NCDOT Signing & Delineation Unit.

• Based on cost-benefit ratio, these results can be used to assist in the selection of pavement marking materials for roadways based on ADT and needed service life.

• The basis for this pavement marking life cycle research is the retroreflectivity of the material which is measured in mcd/lux/m².
History

• Started taking mobile readings around 2000 until the markings were replaced.
• Over 9700 line miles were read.
What do we do with the data?
Parameters & Equations

• Equations
  • Extruded Thermoplastic
  • The Extruded Thermoplastic models used are shown below:

Yellow: \( R_L = 190 + (0.39*R_{L\text{ Initial}}) - (2.09*\text{Time}) - (0.0011*\text{AADT}) - 39.7 \)

White: \( R_L = 190 + (0.39*R_{L\text{ Initial}}) - (2.09*\text{Time}) - (0.0011*\text{AADT}) + 39.7 \)
Parameters & Equations

• **Paint**
  • The model for paint is as shown:

  \[ R_L = 55.2 + (0.77 \times R_{L_{\text{Initial}}}) - (4.17 \times \text{Time}) \]

  • Equations came from NCSU report “Pavement Marking Performance Analysis” by Dr. Joseph Hummer, et. al.
  • In this study data collected from NC roads was used to create degradation models for extruded thermoplastic and paint.
• Notes for Equations

• $R_L$ – Final Retroreflectivity in mcd/lux/m²
• $R_{L \text{ Initial}}$ - Initial Retroreflectivity in mcd/lux/m²
• Time - Time since installation in Months
• AADT - Annual Average Daily Traffic in Vehicles Per Day
• Data used to develop the paint model has an average AADT of 1300
Parameters & Equations

• Initial Retroreflectivity Values
  • The initial retroreflectivity values are based on the minimum standards for each material from the NCDOT 2012 Standard Specifications for Roads and Structures.
  • Higher initial retroreflectivity values increase life to a certain point

• Values Used in Research Study
  • Paint: 200 mcd/lux/m²(Yellow) and 225 mcd/lux/m²(White).
  • Extruded Thermoplastic with Standard Beads: 250 mcd/lux/m²(Yellow) and 375 mcd/lux/m²(White).
  • Polyurea with Highly Reflective Elements: 500 mcd/lux/m² (Yellow), 800 mcd/lux/m² (White)
Material Cost

- Extruded Thermoplastic
  - 4” X 90 Mil (Edge) - $0.45 (Std), $0.62 (HRE) installed
  - 4” X 120 Mil (Middle) - $0.55 (Std), $0.72 (HRE) installed

- Paint
  - All - $0.12 installed per coat
  - Permanent paint markings require 2 coats ($0.24)

- Polyurea
  - All - $0.65 installed (HRE)
Assumptions for Cost Analysis

• The following analysis is based on these criteria:
  
  • The final retroreflectivity ($R_L$) value used was 100 mcd/lux/m².
  
  • Final Retroreflectivity value based on information from AASHTO, MUTCD subcommittee, and Paul Carlson (TTI) study.
  
  • Paint pavement markings will have a life of approximately 1 year when placed in moderate to heavily snowplowed areas.
  
  • Yellow center lines wear quickest due to color and location in roadway.
Chart Explanation

• Charts 1 – 4 show cost per mile on a 2 lane road for four different materials at four different AADTs based on time.
• Charts 5 – 8 show cost per mile on a 2 lane road with moderate to heavy snowplowing for two different materials at four different AADTs based on time.

• Materials shown:
  • Paint with Standard Beads
  • Thermoplastic with Standard Beads
  • Thermoplastic with Highly Reflective Elements
  • Polyurea with Highly Reflective Elements
Notes:
- All bike lane markings should be heated-in-place thermoplastic
Results

1. Savings at 12 years: $16,264 per mile ($1,355 /yr/mile)
Results

2. Savings at 12 years: $21,333 per mile ($1,777 /yr/mile)
Results

3.

Cost per Mile vs. Time
ADT: 5000    ADT Range: 3001-5000
Min. Retro.: 100

Savings at 12 years: $26,402 per mile ($2,200 /yr/mile)
Results

4. Savings at 12 years:
   $46,678 per mile
   ($3,890/yr/mile)
Results

5.

Savings at 12 years: $33,372 per mile ($2,781/yr/mile)
6. Savings at 12 years: $33,372 per mile ($2,781/yr/mile)

Cost per Mile vs. Time
ADT: 3000  ADT Range: 1301-3000
Min. Retro.: 100  Snowplowed
Results

7.

Savings at 12 years: $33,372 per mile ($2,781/yr/mile)

Cost per Mile vs. Time
ADT: 5000    ADT Range: 3001-5000
Min. Retro.: 100    Snowplowed
Results

8.

Savings at 12 years:
$33,372 per mile
($2,781/yr/mile)
### Summary of Analysis

#### Cost per mile at 12 Years

<table>
<thead>
<tr>
<th>AADT</th>
<th>Paint</th>
<th>Thermo (Std)</th>
<th>Thermo (HRE)</th>
<th>Poly (HRE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1300</td>
<td>$30,414</td>
<td>$31,680</td>
<td>$14,150</td>
<td>$27,456</td>
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<td>$35,483</td>
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<tr>
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<td>$40,552</td>
<td>$31,680</td>
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<tr>
<td>10000</td>
<td>$60,828</td>
<td>$31,680</td>
<td>$14,150</td>
<td>$27,456</td>
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</tbody>
</table>

#### Cost per mile at 12 Years - Snowplowed

<table>
<thead>
<tr>
<th>AADT</th>
<th>Paint</th>
<th>Poly (HRE)</th>
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</thead>
<tbody>
<tr>
<td>1300</td>
<td>$60,828</td>
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<tr>
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<tr>
<td>10000</td>
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<td>$27,456</td>
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Most Cost Effective
Summary of Analysis

### Savings per Year Using Long-Life Markings

<table>
<thead>
<tr>
<th>Division</th>
<th>0-1300</th>
<th>1301-3000</th>
<th>3001-5000</th>
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<td>Division 1</td>
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<td>$2,122,000</td>
<td>$3,450,000</td>
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</table>

### Notes:
- Total mileage marked from statewide 2014 data.
- Estimated mileage marked in each Division is based on average percent of 4” paint marking from the past 5 years.
- Estimated mileage marked in each ADT range is a weighted percentage of each Division’s total mileage in that range.
- Division 11 – 14 have moderate to heavy snowplowing
Requirements & Options

- Anticipated Federal Requirements
  - The next version of the MUTCD will likely have minimum retroreflectivity values for pavement markings.
  - Our current practices will not meet these requirements as a whole on our roadway system.

- Options
  - Spend more money marking roadways or,
  - Become more efficient with the money we have by using long-life pavement markings.
Recommendations

• The second option proves to be the most cost effective.

• Immediate Actions

  • Use long-life final markings on all TIP and Resurfacing projects, and in all cases where it is cost effective.

• Future Solutions

  • Use long-life markings on all final applications.
  • This would also lessen worker exposure.
Conclusions

- **Expected Results**
  - Systematically meet minimum retroreflectivity requirements.
  - Save an estimated $15,800,000 a year statewide.
  - A majority of these savings will be from the Highway Fund – General Maintenance.

- **State Forces**
  - Eventually minimize or phase out utilization of state forces for pavement marking operations.
Questions / Comments