Nighttime Visibility of 3M AWP and 3M 380WR ES Durable Tape under Dry, Wet, and Rainy Conditions

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Acknowledgements

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Outline

- Problem Statement
- Objectives
- Background
- Project Information
- Results and Analysis
- Conclusions
- Recommendations for Implementation
- Questions
Problem Statement
Problem Statement

- RPMs are typically used in Ohio to provide visual guidance to motorists under wet weather conditions.
- In rare occasions, the aged pavement surface has failed to provide adequate support to the RPM castings.
- As a result, this project was initiated to evaluate the performance of other alternative materials and determine the feasibility of using them as a replacement for RPMs.
Objectives
Objectives

The main objectives of this study were to:

- Evaluate the wet night performance of alternative wet pavement markings
- Determine the feasibility of using them as a replacement for RPMs in Ohio
Background
Dry and Wet Retroreflectivity
Wet Pavement Markings

Larger Glass Beads  Dual Optics (Elements)  Enclosed Lens Tape

Structured Tape  Profiled Markings
Alternate Marking Technique

Rumble Strip Marking
Project Information
Project Information

Three materials were installed along IR 70 in Licking County (ODOT District 5) following an asphalt resurfacing project.

These materials included:

- 3M All Weather Paint (AWP) – on surface and on rumble strips
- 3M 380WR ES Durable Tape – on surface and in groove
- Standard extruded thermoplastic – on surface and in groove
Project Information (Cont.)

- Test Site Conditions:
  - Average annual snowfall ≈ 20 to 30 inches
- Traffic Conditions (2 lanes per direction)
  - AADT ≈ 44,000 vehicles per day
  - Percentage of trucks ≈ 30%
Project Information (Cont.)

- Pavement markings were installed according to ODOT 2005 Construction and Material Specifications (C&MS)
  - A standard line width of 4 inches was used
  - Yellow markings were installed on the left edge line and white markings were installed on the lane line and right edge line
  - The lane lines were applied in 10 ft long segments with 30 ft gaps in between
## Project Information (Cont.)

<table>
<thead>
<tr>
<th>Treatment No.</th>
<th>Mile Marker</th>
<th>Line Type</th>
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<td>AWP on Rumble Strips</td>
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<td>WR Durable Tape on Surface</td>
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## Project Information (Cont.)

<table>
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<th>Marking Material</th>
<th>Thickness</th>
<th>Reflective Media</th>
<th>Application Rate</th>
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<tr>
<td>3M AWP</td>
<td>20 mil</td>
<td>Type 1 Glass Beads 3M Elements</td>
<td>12 lbs / gallon 5 lbs / gallon</td>
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<tr>
<td>3M 380WR ES</td>
<td>90 mil</td>
<td>Intermixed Microcrystalline Beads</td>
<td>N/A</td>
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<tr>
<td>Thermoplastic</td>
<td>125 mil</td>
<td>Type C Glass Beads</td>
<td>12 lbs / 100 ft²</td>
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Performance Evaluation Plan

Pavement Marking Performance

Dry Performance
- Dry Retroreflectivity
- Dry Visibility Distance
- Color
- Durability

Wet Performance
- Wet Retroreflectivity
- Wet Visibility Distance
Performance Evaluation Plan

- Quantitative measures:
  - Dry and wet retroreflectivity (Delta LTL-X Retroreflectometer)
  - Color (Miniscan XE Plus Colorimeter)

- Qualitative measures:
  - Dry and wet visibility distance
  - Durability (0 – 10)
Retroreflectivity (Delta LTL-X)
Retroreflectivity (30 m Geometry)
Daytime Color (Miniscan XE Plus)
Result and Analysis
Dry and Wet Retroreflectivity
Wet Retroreflectivity (YEL)

![Graph showing wet retroreflectivity (YEL) over time and different treatments.]

- Initial
- 6 Months
- 1 Year
- 1.5 Years

- 3M AWP on Rumble Strips
- 3M 380WR ES Tape on Surface
- 3M 380WR ES Tape in Groove
- Thermoplastic in Groove
- 3M AWP on Surface
- Thermoplastic on Surface
Dry Retroreflectivity (WLL)

Retroreflectivity, $R_L$ (mcd/m$^2$/lux)

- 3M AWP on Surface
- 3M 380WR ES Tape on Surface
- 3M 380WR ES Tape in Groove
- Thermoplastic in Groove
- Thermoplastic on Surface
- Thermoplastic on Surface

Initial 6 Months 1 Year 1.5 Years
Wet Retroreflectivity (WLL)
Dry Retroreflectivity (WEL)

Retroreflectivity, $R_L$ (mcd/m$^2$/lux)

Initial 6 Months 1 Year 1.5 Years

3M AWP on Rumble Strips 3M 380WR ES Tape on Surface 3M 380WR ES Tape in Groove Thermoplastic in Groove 3M AWP on Surface Thermoplastic on Surface
Wet Retroreflectivity (WEL)
Dry and Wet Visibility Distance
Dry Visibility Distance (YEL)
Wet Visibility Distance (YEL)

![Graph showing wet visibility distance for different materials and conditions over time.]

- **3M AWP on Rumble Strips**
- **3M 380WR ES Tape on Surface**
- **3M 380WR ES Tape in Groove**
- **Thermoplastic in Groove**
- **3M AWP on Surface**
- **Thermoplastic on Surface**

The graph compares the wet visibility distance for various materials and conditions over initial, 6 months, 1 year, and 1.5 years.
Dry Visibility Distance (WLL)

![Bar graph showing dry visibility distance for different materials and conditions over time.]

- **Initial**
- **6 Months**
- **1 Year**
- **1.5 Years**

Materials and conditions:
- 3M AWP on Surface
- 3M 380WR ES Tape on Surface
- 3M 380WR ES Tape in Groove
- Thermoplastic in Groove
- 3M AWP on Surface
- Thermoplastic on Surface
- Thermoplastic on Surface
Wet Visibility Distance (WLL)

- Wet Visibility Distance (ft)
- Initial
- 6 Months
- 1 Year
- 1.5 Years

Bar chart showing wet visibility distance for different materials:
- 3M AWP on Surface
- 3M 380WR ES Tape on Surface
- 3M 380WR ES Tape in Groove
- Thermoplastic in Groove
- Thermoplastic on Surface
- Thermoplastic on Surface
Dry Visibility Distance (WEL)

![Graph showing the comparison of dry visibility distance for different materials and application methods. The x-axis represents different materials and application methods: 3M AWP on Rumble Strips, 3M 380WR ES Tape on Surface, 3M 380WR ES Tape in Groove, Thermoplastic in Groove, 3M AWP on Surface, Thermoplastic on Surface. The y-axis represents the dry visibility distance in feet. The graph compares the initial, 6 months, 1 year, and 1.5 years data points for each material and application method. The data shows that Thermoplastic in Groove generally has the longest dry visibility distance compared to other materials and application methods.]

- **3M AWP on Rumble Strips**
- **3M 380WR ES Tape on Surface**
- **3M 380WR ES Tape in Groove**
- **Thermoplastic in Groove**
- **3M AWP on Surface**
- **Thermoplastic on Surface**
Wet Visibility Distance (WEL)
Dry Visibility Distance (RPMs)
Wet Visibility Distance (RPMs)

![Wet Visibility Distance Chart]

- Mile Marker 138-139 (EB)
- Mile Marker 139-140 (EB)
- Mile Marker 140-141 (EB)
- Mile Marker 141-142 (EB)
- Mile Marker 142-143 (EB)
- Mile Marker 138-143 (WB)

- Initial
- 6 Months
- 1 Year
- 1.5 Years

Retroreflectivity, $R_L (\text{mcd/m}^2/\text{lux})$
CIE Color Diagram

ODOT Yellow Color Specifications

ODOT White Color Specifications
Color (e.g., 3M AWP, YEL)
Color (e.g., 3M AWP, WLL)
Color (e.g., 3M AWP, WEL)
Durability
Durability

- Almost all materials performed satisfactorily throughout the first year of evaluation.
- 3M AWP installed on rumble strips had a drop in durability after the first year.
- During the second winter season, the WR durable tape installed on the surface was caught by snowplows in many locations.
Service Life Prediction
# Retroreflectivity Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Equation</th>
<th>Formulate $R_L$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear Model</td>
<td>$y = a + bx$</td>
<td>$R_L = a + b . \text{Age}$</td>
</tr>
<tr>
<td>Power Model</td>
<td>$y = a . x^b$</td>
<td>$R_L = a . \text{Age}^b$</td>
</tr>
<tr>
<td>Exponential Model</td>
<td>$y = a e^{b x}$</td>
<td>$R_L = ae^{b . \text{Age}}$</td>
</tr>
<tr>
<td>Natural Logarithmic</td>
<td>$y = a + b \ln(x)$</td>
<td>$R_L = a + b . \ln(\text{Age})$</td>
</tr>
<tr>
<td>Model</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Retroreflectivity Modeling

- The model parameters $a$, $b$ and $c$ were obtained using MS Excel.
- The exponential model provided the most reasonable estimates of the pavement markings service lives.
Retroreflectivity (WEL 3M AWP on Surface)
Retroreflectivity (WEL 3M AWP on Rumble Strips)

![Graph showing the relationship between age and retroreflectivity for dry and wet conditions.](image)
Retroreflectivity (WEL 3M 380WR ES on Surface)
Retroreflectivity (WEL 3M 380WR ES in Groove)

![Graph showing the change in retroreflectivity over age (Days) for dry and wet conditions.](image-url)
Retroreflectivity (WEL Thermoplastic on Surface)

![Graph showing retroreflectivity over age (days) for dry and wet conditions.](image)

- **Retroreflectivity, $R_L$ (mcd/m$^2$/lux)**
- **Age (Days)**
- **Dry**
- **Wet**
Retroreflectivity (WEL Thermoplastic in Groove)
Estimated Service Life
<table>
<thead>
<tr>
<th>Treatment Type</th>
<th>Line</th>
<th>Dry</th>
<th>Wet</th>
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</thead>
<tbody>
<tr>
<td>3M AWP on Rumble Strips</td>
<td>YEL</td>
<td>3.3</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>3M AWP on Surface</td>
<td>WLL</td>
<td>3.1</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>3M AWP on Rumble Strips</td>
<td>WEL</td>
<td>2.8</td>
<td>&lt; 0.5</td>
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<tr>
<td>3M AWP on Surface</td>
<td>YEL</td>
<td>6.0</td>
<td>2.4</td>
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<tr>
<td>3M 380WR ES on Surface</td>
<td>WLL</td>
<td>2.7</td>
<td>0.9</td>
</tr>
<tr>
<td>3M 380WR ES on Surface</td>
<td>WEL</td>
<td>2.6</td>
<td>0.6</td>
</tr>
<tr>
<td>3M 380WR ES in Groove</td>
<td>YEL</td>
<td>7.7</td>
<td>2.3</td>
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<tr>
<td>3M 380WR ES in Groove</td>
<td>WLL</td>
<td>4.0</td>
<td>0.6</td>
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<td>3M 380WR ES in Groove</td>
<td>WEL</td>
<td>2.0</td>
<td>0.8</td>
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<tr>
<td>Thermoplastic in Groove</td>
<td>YEL</td>
<td>10.8</td>
<td>&lt; 0.5</td>
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<td>Thermoplastic in Groove</td>
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<td>6.5</td>
<td>&lt; 0.5</td>
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<tr>
<td>Thermoplastic in Groove</td>
<td>WEL</td>
<td>1.9</td>
<td>&lt; 0.5</td>
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<td>WEL</td>
<td>1.1</td>
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Life Cycle Cost Analysis
Life Cycle Cost Analysis (LCCA)

- One maintenance strategy was used in performing the analysis. It included restriping with traffic paint at the end of service life every year until the end of the analysis period.

- The following equation was used in the analysis

\[ PV = A_o + \sum A_t \left( \frac{1}{1+i} \right)^t \]

- Assume, analysis period, \( t = 6 \) yrs and rate of return, \( i = 4\% \).
# Life Cycle Cost Analysis (LCCA)

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Assumed Service Life (yrs)</th>
<th>Installation Cost ($/mile)</th>
<th>Removal Cost ($/mile)</th>
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<tr>
<td></td>
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<td>Grooving</td>
<td>Edge Line</td>
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<tr>
<td>3M All Weather Paint</td>
<td>1 to 2</td>
<td>N/A</td>
<td>1,990</td>
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<tr>
<td>3M 380WR ES on Surface</td>
<td>3 to 5</td>
<td>N/A</td>
<td>12,702</td>
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<tr>
<td>3M 380WR ES in Groove</td>
<td>3 to 5</td>
<td>4,478</td>
<td>12,702</td>
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<tr>
<td>Thermoplastic on Surface</td>
<td>1 to 3</td>
<td>N/A</td>
<td>1,680</td>
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<tr>
<td>Thermoplastic in Groove</td>
<td>1 to 3</td>
<td>4,478</td>
<td>1,680</td>
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<tr>
<td>RPMs</td>
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<tr>
<td>Material Type</td>
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<td>Present Value ($/mile)</td>
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<td>-------------------------------</td>
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<td>4,130</td>
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<td>RPMs</td>
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Conclusions
Conclusions

- 3M AWP had relatively high initial dry and wet retroreflectivity. However, it lost most of its wet retroreflectivity during the first winter season. Therefore, this product would require regular restriping to maintain a reasonable level of wet visibility, which may not be cost effective.

- 3M 380WR ES durable tape lost most of its wet visibility in less than 1.5 years. Therefore, it will not be cost effective to use this relatively expensive material as a replacement for RPMs to guide motorists under inclement weather conditions.
Conclusions (Cont.)

- When installed on the surface, 3M 380WR ES durable tape was caught by snowplows. Therefore, this material must be installed in groove to protect it from snow plowing activities.
Recommendations for Implementation
Recommendations

- RPMs provided the longest wet night visibility distance throughout this study. Therefore, it is recommended to continue to use them in Ohio to provide wet night visibility.

- It is also advised to continue to check the condition of the RPMs from time to time, especially on aged asphalt pavements, to ensure proper adhesion to the pavement surface.
Recommendations (Cont.)

- While rare incidents have occurred where an RPM detached from an aged pavement surface, it is believed that RPMs prevent countless crashes during inclement weather conditions.
- Furthermore, RPMs help snowplow truck drivers detect the center of the roadway when roads are covered with snow.
Questions?