Importance of Pavement Marking Retroreflectivity Standards

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- Research aspects of traffic control materials with emphasis on safety and visibility
ASTM Standards

- ASTM E1710-11  Dry Handheld Test Method
- ASTM E2177-11  Wet Recovery Handheld Test Method
- ASTM E2176-08  Wet Continuous Handheld Test Method
- ASTM E2832-12  Wet Continuous Handheld Test Method
- ASTM D7585-10  Handheld Sampling Protocol
- ASTM WK3833  Mobile pavement marking Work Item
ASTM E1710-11

- Measurements of dry pavement marking retroreflectivity
- Defines instrument geometry
- Refers to D7585 for sampling plan
- “surface of marking shall be clean and dry”
- Recently added Precision Bias statement
Precision & Bias

- Testing completed in Feb 2010
<table>
<thead>
<tr>
<th>Sample</th>
<th>Average of the Labs' Averages</th>
<th>R/mean</th>
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<td>N</td>
<td>575.8</td>
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<tr>
<td>D</td>
<td>331.4</td>
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<tr>
<td>Ap</td>
<td>266.5</td>
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<td>O</td>
<td>508.7</td>
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<td>R</td>
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<td>At</td>
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<td>K</td>
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<td>Q</td>
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<td>H</td>
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<td>F</td>
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</table>
ASTM E2177-11

- Measurement of wet recovery (after rain)
- Currently includes option for dump or spray method
- Recently added Precision Bias statement
- Most commonly specified wet TM
Testing completed in Feb 2010
ASTM E2176-08

- Measurement of continuously wetted pavement markings (during rain)
- Limited to markings with optics having index of refraction greater than 2.0 and structured markings having vertical surfaces ≥ 3 mm
- Controversial (wetting rate > 9 iph)
Measurement of continuously wetted pavement markings (during rain)

Based on wetting rates of 2 inches per hour
E2832 Field Data

Test Method and Location (EL=Edgeline, LL=Laneline)

- DRY EL
- DRY LL
- RECOV EL
- RECOV LL
- WET EL
- WET LL

Retroreflectivity (mcd)

30 day
60 day

E1710
E2177
E2832
E2832 Dispersion

Average of 8 Pvmr Mtg systems (4 binders with 2 different optics each)

<table>
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<tr>
<th>Coefficient of Variation (σ/μ)</th>
<th>0.180</th>
<th>0.160</th>
<th>0.140</th>
<th>0.120</th>
<th>0.100</th>
<th>0.080</th>
<th>0.060</th>
<th>0.040</th>
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</table>

Legend:
- 30day
- 60day

Binders:
- E1710
- E2177
- E2832
Sampling protocol for using handheld retroreflectometers

3 field techniques, including number of measurements needed

Does not set initial or maintained minimum $R_L$ levels

Released August 2010
Evaluation techniques

- Nighttime Visual Inspection
- Standard Evaluation Protocol
- Referee Evaluation Protocol
New or in-service markings
Look for low brightness or high variability
  • If any, conduct daytime inspection using Standard Evaluation protocol
  • If none, record 4 random measurements
ASTM D7585-10
Standard Evaluation Protocol

- Intended for longitudinal markings
- Evaluation sections: 400 ft (minimum)
- At least 16 readings per evaluation section
  - Based on statistical valid sample sizing
Evaluation Section:
Less than 2 miles

2 measurements per skip line for 10 skip lines

20 measurements made approx 20 feet apart

400 ft
Evaluation Section:
More than 2 miles

Three evaluation sections as shown in Figure 1.

> 2 miles
ASTM D7585-10
Referee Evaluation Protocol

- Most rigorous protocol
- Minimum of 20 measurements per Evaluation Section
- Includes all marking types such as arrows and gore markings
ASTM WK3833

- In-development
- Test method for mobile pavement marking retroreflectivity measurements
Why is this important?

- FHWA is working on minimum maintained pavement marking retroreflectivity levels for the MUTCD
- Once adopted, agencies will have to maintain pavement marking retroreflectivity
Pavement Marking Retroreflectivity = Safety

- An Investigation of Longitudinal Pavement Marking Retroreflectivity and Safety
  - TRB Annual Meeting, Paper Number 13-2512

- Objective
  - Determine whether a correlation exists between pavement marking retroreflectivity and safety
Our Approach

- Merge Michigan crash, roadway, and retroreflectivity databases
  - Rural two-lane highways and freeways
  - Only non-intersection/interchanges segments
  - Only nighttime crashes
  - Only non-winter data from 2002 to 2008
    - April to October (7 months per year)
Retroreflectivity Data

- About 25,000 measurements
- Mobile measurements (1.25 million readings)
- About 15% of the state system each year
- Four line types
  - White edge line, white lane line
  - Yellow edge line, yellow center line
- Michigan restripes about 80-85% of their system each year
Distribution of Retro by Line Type

- W Edge
- W Lane
- Y Center
- Y Edge

Legend:
- W Edge
- W Lane
- Y Center
- Y Edge

- Number of Obs.
- 100 mcd or less
- 100-150 mcd
- 150-200 mcd
- 200-250 mcd
- 250-300 mcd
- 300-350 mcd
- 350-400 mcd
- 400-450 mcd
- Over 450 mcd
Database Development

- For each segment, 49 time periods
  - 7 years, 7 months per year
- To populate retro for each segment
  - Temporal imputation
    - Rules for degradation per month generated from subset of data
  - Spatial imputation
    - Backward and forward imputation performed
Analyses Technique

- Negative binomial regression with Generalized Estimating Equations (GEE)
- Analyses were conducted 4 ways:
  - With all the retro data
  - With retro data < 200 mcd
  - With retro data < 150 mcd
  - With retro data < 100 mcd
Partial Findings: Single Vehicle Nighttime Crashes on Freeways

- **White edge lines**
  - NB coeff. -0.009 (statistically significant)
  - Increase retro by 10 mcd → 0.9% reduction
  - Increase retro by 100 mcd → 8.6% reduction

- **Yellow edge lines**
  - NB coeff. -0.013 (statistically significant)
  - Increase retro by 10 mcd → 1.3% reduction
  - Increase retro by 100 mcd → 12.2% reduction
Suggested Actions

- Get ahead of FHWA
- Implement minimum pavement marking retro standards for long line markings
- Use warranty or performance specifications with ASTM test methods
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