

Wet Retroreflectivity for Road Safety

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- **What is Wet Retroreflectivity?**

- Wet retroreflectivity refers to the visibility of road markings during wet conditions, where traditional markings often become less effective.
- Importance: Enhancing visibility in adverse weather conditions can significantly reduce crashes and improve road safety.

- **Challenges Addressed by Wet Retroreflectivity:**

- Reduced visibility during rain, fog, and nighttime conditions.
- Increased risk of crashes due to poor road marking visibility.
- The necessity for advanced materials and technologies to maintain road safety.

Objectives:

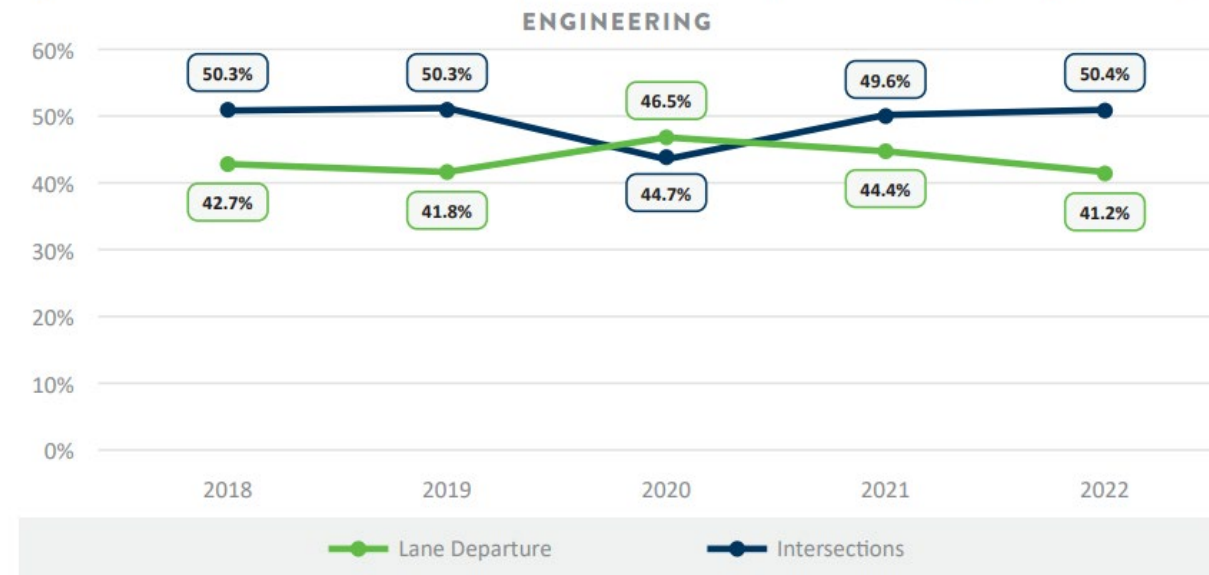


- Present the latest advancements in wet retroreflectivity technology.
- Showcase data and research on crash reduction on roads equipped with wet weather elements.
- Highlight the benefits and implementation strategies for improved road safety.

Importance

- Single vehicle road departures are over 40% of all Minnesota fatalities and serious injuries.
 - These crashes were widely distributed across the entire state and local network, with horizontal curves making up a disproportionate amount.
 - When looking at how low the crash density (~0.01 severe road departure/mile/year) is, pavement markings are extremely cost effective to cover an entire system.
 - Road departures are especially prevalent on rural county highways, which is why MnDOT has been an advocate for local safety planning and providing HSIP money for locals.
 - It's not the road departure that's the main concern, it's what happens afterwards!

Figure 11. Annual Statewide Fatal and Serious Injury Crash Prevalence by Focus Area – Engineering (2018-2022)





Challenges:

In 2018, 2,884 people died in crashes on U.S. roads when it was raining

59% (or 1,689) of those deaths occurred at night or in low light conditions



Bright road markings provide better preview time

Because they're visible from longer distances, brighter road markings give drivers more time to react at higher speeds.

² ***Pavement Markings—Wet Retroreflectivity Standards.*** Minnesota Department of Transportation. (March 2020). Adam Pike, Principal Investigator. <http://www.dot.state.mn.us/research/reports/2020/202009.pdf>. (Retrieved September 17, 2021).



Yellow – Regular Pavement Markings

White – Wet RetroReflective Pavement Markings

Wet Retroreflectivity

“Pavement Markings - Wet Retroreflectivity Standards” research study

- 50 mcd/m²/lux wet continuous retroreflectivity was found to be the minimum to make emergency maneuver at 55 mph
- Through analyzing degradation of markings in MN, 200 mcd/m²/lux was suggested for initial install
 - Through tracking installed projects, MnDOT will adjust this if data shows we can attain an acceptable retro above 50 mcd/m²/lux if starting at a lower initial value.
- A Special Provision was put together to test and require the minimum initial
 - WR testing can be done through mobile retroreflectometer contractors using ASTM E 2832 Continuous Wetting method or approved equivalent
 - Has been used widespread on MnDOT resurfacing projects since 2022



Wet Retroreflectivity Research

- FHWA Safety Evaluation of Wet-Reflective Pavement Markings, 2015

- FHWA-HRT-15-083

Table 4. Economic analysis results.

	B/C Ratio		
	Point Estimate	Lower Bound	Upper Bound
Freeways	1.45	0.83	2.04
Multilane Roads	5.44	3.1	7.67

- Benefits to Cost Ratio (B/C) assuming 2 year service life.
- Benefit B = value of crash costs avoided.
- Cost C = cost to install the safety measure
- Recommended USDOT sensitivity analysis applied to factors.

Table 5. Recommended CMFs and standard errors.

	Total	Injury	Run-Off-Road	Wet-Road	Nighttime
Freeways		0.881 (0.033)		0.861 (0.040)	
Multilane Roads	0.825 (0.051)	0.595 (0.059)	0.538 (0.078)	0.751 (0.108)	0.696 (0.082)

Blank cell = No CMF is recommended.

⁶ FHWA Safety Evaluation of Wet-Reflective Pavement Markings, 2015 FHWA-HRT-15-083. <https://www.govinfo.gov/content/pkg/GOVPUB-TD2-PURL-gpo65113/pdf/GOVPUB-TD2-PURL-gpo65113.pdf>

Comments:

“These results suggest that the treatment—even with conservative assumptions on cost, service life, and the value of a statistical life—can be cost effective, especially for multilane roads.”

Wet Retroreflectivity Research

- Safety effects of wet-weather pavement markings

- Eun Sug Park, Paul J. Carlson, Adam Pike, Texas A&M Transportation Institute, Texas A&M University System, Published in *Accident Analysis and Prevention*



- Results

Table 6
Comparison of Safety Effectiveness Estimates for Wet-Weather Pavement Markings Obtained by Different Before-After Evaluation Approaches.

Approach	Percent Crash Reduction (Uncertainty Estimate)					
	Wet- Night	Dry- Night	Wet-Night Fatal Injury	Dry-Night Fatal Injury	Wet-Night Run Off Road	Dry-Night Run Off Road
EB	28% (11%)	7% (8%)	53% (12%)	16% (10%)	25% (13%)	12% (8%)
FB	33% (12%)	2% (11%)	55% (15%)	3% (16%)	17% (19%)	1% (14%)

Note: 1. Uncertainty estimate is standard error for EB and posterior standard deviation for FB; 2. Statistically significant results with 95% (90%) confidence/probability are shown in bold (*italic*).

Summary

Research links wet reflective markings to helping reduce crashes

46%

Reduction in run-off-road crashes on multi-lane roads with *Wet-Reflective Pavement Markings*^{6 7}

53%

Reduction in wet-night fatal Injury with *Wet-Reflective Pavement Markings*⁸

Benefit / Cost = 5.44/1



Wet Retroreflectivity Research

All Freeways and US-2

- Compares 3 years of pre-implementation crash data to 3 years of post-implementation crash data
- Implementation year was 2018 for I-96 and I-75, and 2019 for the rest of the routes
- Focused on wet and lane departure crash types
- Unable to determine how much of a factor COVID-19 was in these numbers

Michigan Crash Reduction chart for Wet-Reflective Pavement Markings

Crash Type	Reduction
All Crashes	28%
Fixed Object	23%
Sideswipe	17%
All Wet Crashes	31%
Wet Night Crashes	28%

⁹ Michigan Crash Reduction Study for *Wet-Reflective Pavement Markings*, Michigan DOT, Mary Bramble

Conclusions

- Crash studies show that Wet Reflective Pavement Markings at night in wet weather conditions:
 - Lower crashes
 - Reduce injuries and deaths
- Crash study cost analysis indicates savings from preventing crashes saves up to 5.44 times the cost to implement Wet-Reflective Pavement Markings



Thank you!

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