Pavement Markings and Safety

tech transfer summary

In evaluating the service life of roadway pavement markings, how often should agencies restripe and repair these markings?

Objective

This study explores the statistical relationship between crash occurrence probability and longitudinal pavement marking retroreflectivity.

Problem Statement

Previous research on pavement markings, from a safety perspective, tackled various issues, such as pavement marking retroreflectivity variability, relationship between pavement marking retroreflectivity and driver visibility, and pavement marking improvements and safety.

A recent research interest in this area is to find a correlation between retroreflectivity and crashes, as a significant statistical relationship is undefined to date.

Background

Longitudinal pavement markings provide guidance to road users by delineating the traveled way. These markings help protect drivers by indicating where they should be on the road to prevent collisions with other vehicles, as well as to prevent run-off-the-road crashes. Pavement markings are especially important at night.

Retroreflectivity

Pavement marking retroreflectivity is measured in units of millicandelas per square meter per lux (mcd/m2/lx) and is a critical measure of pavement marking performance. Glass spheres (or "beads") are recessed into the pavement markings to reflect light back to the driver. The amount of light that is reflected back to the light source is defined as the retroreflectivity.

Variability of Retroreflectivity

Pavement marking retroreflectivity can vary significantly by location. One segment may have a high retroreflectivity value, while a segment just a few feet away may have a low value. Potential causes of this variability include damage due to traffic or winter maintenance, environmental conditions, and the consistency in which the pavement markings were both applied and measured. This variability makes it difficult to summarize pavement marking retroreflectivity by roadway segment.

Service Life Evaluation/Degradation of Pavement Markings

In Iowa (and other states with significant winter maintenance operations), the reflective beads embedded in the paint can be severely damaged by snowplows. Other than snowplow damage, pavement markings wear out over time from traffic, and agencies must restripe and repair the condition of pavement markings on a regular basis.

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RESEARCH PROJECT TITLE
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Some agencies have established minimum thresholds for pavement markings. For example, the Iowa Department of Transportation currently uses 150 mcd/m2/lx for white markings and 100 mcd/m2/lx for yellow pavement markings as a minimum standard for restriping state highways.

Research Description

This study analyzed five years of pavement marking retroreflectivity data, collected by the Iowa Department of Transportation (DOT) on all state primary roads, and the corresponding crash and traffic data.

The research team developed a spatial-temporal database, using measured retroreflectivity data to account for the deterioration of pavement markings over time, along with statewide crash data, to attempt to quantify a relationship between crash occurrence probability and pavement marking retroreflectivity.

Crashes that occurred in daylight, under good lighting conditions, or under unknown conditions were not included in the data set, because the study was interested in the effect of retroreflectivity under dark conditions. Crashes during dawn, dusk, and dark conditions with no roadway lighting were, therefore, selected as possible target crashes.

Target crash selection was finalized by selecting only the lane departure crashes not caused by: an animal or object in the roadway, a collision with another vehicle, avoiding a collision with another vehicle, or equipment problems.

The target crash data were then matched with the retroreflectivity data by location. The final data set contained representative retroreflectivity values for each available milepost, with accompanying variables, such as vehicle miles traveled, line type, direction of reading, road type, route number, and crash information, when available.

Two types of logistic regression analyses were completed for this study—standard logistic regression and logistic regression with a subject effect. When the data were divided by line type, the data structure for the resulting four subsets allowed the second type of analysis, where a subject effect for each route could be assigned.

This subject effect in the model recognizes the observations from the same route and the correlation between these observations, because they come from the same subject (same route for our analysis). This change in the model improves the model by separating the variation, within each route, from the overall variation in the data. Therefore, the statistical relationship between crash occurrence and pavement marking retroreflectivity can be better analyzed.

Key Findings

Pavement marking retroreflectivity was found to have a significant effect in crash occurrence probability for four data subsets—interstate, white edge line, yellow edge line, and yellow center line data.

Dividing the data by line type into three subsets enabled the inclusion of a subject effect for routes into the logistic regression model. Including the routes as a subject effect addresses the autocorrelation from the readings that come from the same route.

For this set of logistic regression analyses, retroreflectivity was found to be a significant parameter for all line types—at 90% confidence level for white edge lines, 95% confidence level for yellow edge lines, and 99% confidence level for yellow center lines.

For white edge lines and yellow center lines, crash occurrence probability was found to increase—by decreasing values of longitudinal pavement marking retroreflectivity.

Implementation Benefits

Many studies have tested the visibility and subjective preferences of drivers against pavement markings with a known retroreflectivity. Others have compared crashes by location to either measured or modeled pavement marking retroreflectivity values.

All of these studies are concerned with determining a relationship between pavement marking retroreflectivity and safety. With this relationship identified, agencies can evaluate the service life of their pavement markings much more efficiently and improve their asset management programs, along with the allocation of their scarce resources.

Implementation Readiness/ Recommendations

These findings provide a statistical link between pavement marking retroreflectivity levels and crash history. Along with the Federal Highway Administration's proposed minimum retroreflectivity standards, these findings support increased investment in marking application and maintenance and also serve as a foundation for future research on this critical safety asset.