

Traffic Sign Life Expectancy

tech transfer summary

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RESEARCH PROJECT TITLE

Traffic Sign Life Expectancy

SPONSOR

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The mission of the Institute for Transportation (InTrans) at Iowa State University is to develop and implement innovative methods, materials, and technologies for improving transportation efficiency, safety, reliability, and sustainability while improving the learning environment of students, faculty, and staff in transportation-related fields.

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The information and analysis produced through this project should be of value to agencies in Iowa in understanding the service life of signs in the field and more effectively applying their selected assessment or management method of sign maintenance and replacement.

Problem Statement

While traffic signs are a critical component in providing drivers with warning and guidance along roadways, they also represent a significant maintenance and replacement concern and cost for agencies, particularly at the local level. Sign sheeting warranty information or other guidance from a manufacturer provide a recommended life estimate. However, over time, observations of older signs have revealed retroreflectivity levels well above the minimum required levels on signs that have been in service much longer than the manufacturer warranty period.

The implications of this are clear: some signs may be replaced based on the recommended service life yet still exceed minimum retroreflectivity requirements. Consequently, agencies may replace their signs at a significant cost based on a given time cycle when the signs may still have several more years of service life remaining.

Project Goal and Objective

The goal of this project was to investigate and determine what the expected sign life values are, based on retroreflectivity measurements for different categories/types of signage, and how these compare to manufacturer warranty ages. The primary objective is to provide local agencies information in a format useful in understanding the expected life for their different signage in the field based on its characteristics (i.e., sheeting type, color, and directional orientation).



David Veneziano, Iowa LTAP

Retroreflective curve warning sign with an advance speed warning plaque

Background

Maintenance and replacement requirements have increased following the Federal Highway Administration's (FHWA's) Manual on Uniform Traffic Control Devices (MUTCD) compliance date requirement of June 2014 for agencies to implement and use an assessment or management method for maintaining sign retroreflectivity.

The purpose of these assessment or management methods is to maintain minimum retroreflectivity standards for regulatory and warning signs. Retroreflectivity is the characteristic of sign sheeting material that reflects light off the sign back to its source (vehicle headlights).

State, county, and municipal jurisdictions own and manage thousands of signs. The regulatory, warning, and guidance information that these signs convey to drivers serves an important safety function, both during the day and at night. Sign retroreflectivity is a critical aspect in ensuring signs are visible to drivers at night, and, to this end, departments of transportation (DOTs) and local agencies expend significant labor and financial resources to ensure that regulatory and warning signs meet the minimum requirements as laid out in the MUTCD Section 2A.08.

Research Description

This project attempted to evaluate the retroreflectivity service life of in-service signage to determine expected sign life values. The approach taken to complete the project was as follows.

The researchers performed a literature search and review of published research and resource documents, focusing on past studies that examined the deterioration rates of sign sheeting. These documents and their results are summarized in the final report.

Concurrently with the literature review, the researchers identified local agencies in Iowa that had been using a retroreflectometer to measure and record sign retroreflectivity data as part of their assessment or management approach toward maintaining minimum retroreflectivity requirements. Those agencies were asked if they were willing to share their data for analysis as part of this research. The researchers acquired the data from the agencies that were willing to share their data in support of the subsequent analysis.

Next, the team performed data quality control activities to ensure that the data to be evaluated were formatted and complete. This was followed by determining the analysis approach to use to evaluate the retroreflectivity data, in part based on what similar efforts have been used, as well as on what was most appropriate for the data.

With the data analysis approach established, the researchers performed data analysis to determine the expected service life for a particular sheeting material,



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Use of retroreflectometer to measure and record sign retroreflectivity data on a Stop sign

sign color, sign orientation/direction, etc. The data analysis included the development of 65 different linear regression models to estimate the age at which signs of a given combination of sheeting material, color, and directional orientation could be expected to fall below the MUTCD minimum retroreflectivity values.

The final task was to compile the final report to assist local agencies in understanding the expected service life of signs in the field and more effectively apply or modify their selected sign assessment or management method(s).

To summarize, as part of the work, past in-service sign retroreflectivity research was documented, local agency retroreflectivity data were collected, data analysis and comparisons were performed, and conclusions and recommendations were developed based on the analysis and results.

Key Findings

- Most prior studies only focused on evaluating the expected life of in-service Type I and Type III sheeting material.
- The models developed in past studies did not always explain the relationship between retroreflectivity and sign age, as evidenced by generally low coefficient of determination (R^2) values. Some past studies did observe the potential for red Type III signs to increase in retroreflectivity over time.
- It was reported in the literature that failure rates for signs falling below MUTCD minimums were generally lower than 10 percent.
- Based on the estimated ages produced from the various regression equations and plots of retroreflectivity versus age for different combinations, all signs were expected to last more than 10 years before retroreflectivity fell at or below the MUTCD minimums.

- Plots of sign retroreflectivity versus sign age indicated that many retroreflectivity readings still remained well above the MUTCD minimums at the predicted age where failure was expected.
- In general, the results produced by the research were similar to those of past studies, including R² values and the general trends produced when plotting retroreflectivity data over time.
- For most sheeting materials and sign types/colors, it appears that the expected sign lives extend beyond the manufacturer warranty period by approximately five years.
- While not conclusive from a statistical perspective, the results of the evaluations conducted in this research did not indicate that the retroreflectivity of south- or west-facing signs deteriorated at any greater rate than that of other signs. This is true of both the estimated age trend lines as well as the general data plots of retroreflectivity values.

Limitations

- The data available to this research were assumed to have been collected uniformly. In reality, this may not have always been the case. Different agencies and data collectors likely employ different approaches (cleaning versus not cleaning signs, number of readings collected per sign, etc.) when measuring sign retroreflectivity.
- In some cases, the presence of many retroreflectivity readings that were well above MUTCD minimums even at an older sign age likely contributed to some of the larger, more unrealistic expected sign life estimates (i.e., 25+ years to failure). This was particularly true for cases like High Intensity Prismatic Stop signs.

Implementation Readiness and Benefits

Sign retroreflectivity can have various impacts on transportation agencies. From a monetary standpoint, some agencies rely on using a manufacturer's estimated service life values or warranty periods to guide their sign management program and meet MUTCD retroreflectivity compliance. In using such an approach, signs are replaced in conjunction with the end of those timeframes, even if the retroreflectivity of the sign itself still exceeds the minimums specified in the MUTCD. The result is that new signs may be purchased and installed before replacement of the prior sign is necessary, with unnecessary material and labor costs being incurred.

Some agencies collect direct measurements of sign retroreflectivity values, and this activity also has a cost in terms of labor, particularly if all signs in a jurisdiction are measured on a shorter timeline (yearly, bi-yearly). Cost and time savings can be achieved if the duration between measurement intervals could be extended (and possibly supplemented by nighttime drive-by inspections), even if that extension is only one extra year.

The results of this project are expected to be of value to agencies in understanding the in-service life of signs and in applying this information as necessary to their selected assessment or management method for determining inspection intervals, replacement cycles, etc.

While some of the estimated sign ages were more reliable than others, as evidenced by the R² values that were produced by some models, suggested expected sign life values of 12 to 16 years are recommended for agency consideration. These suggested values are largely conservative, particularly when compared to the predicted age that a sign would fall below MUTCD minimums, which was generally above 15 years of age.

Predicted sign life age vs. suggested sign life

Sheeting Material	Sign Type	Color	Predicted Age (years)					Suggested Sign Life (Years)
			All Signs	East	North	South	West	
Engineering Grade (Type I)	Stop	White	16.55	13.06	46.3	15.15	13.78	13
		Red	14.98	15.24	26.67	14.86	13.00	13
	Regulatory	White	16.35	51.36	12.79	16.27	16.47	15
	Warning*	Yellow*	12.39	12.55	12.64	11.96	12.22	12
High Intensity Prismatic (Type III/IV)	Stop	White	24.31	21.48	14.45	39.86	23.64	14
		Red	61.84	34.41	55.07	97.67	57.38	15
	Regulatory	White	16.96	15.76	16.8	21.83	14.46	15
	Warning	Yellow	17.18	17.48	17.12	16.09	18.55	16
	Guide	White	81.06	25.84	17.65	10.34	infinity	10**
		Green	25.63	14.45	17.91	48.09	16.58	10**
Diamond Grade (Type IX)	Stop	White	29.54	30.36	26.01	27.81	30.72	15
		Red	29.57	27.95	24.57	30.86	35.41	15
	Warning	Yellow	29.22	38.23	15.36	24.86	12.93	15

* The MUTCD states that this sheeting shall not be used for this sign type. Results are for informational purposes only.

** The manufacturer's warranty period is suggested for use with these signs, as inadequate data were available to establish reasonable age predictions.

Inspection Recommendations

- Agencies should employ some form of inspection procedure past the manufacturer's warranty age to ensure that signs do not fail to meet MUTCD retroreflectivity requirements prematurely. However, by employing the baseline of five additional years of service beyond the warranty period, an agency can reasonably expect to produce cost savings through reduced sign purchasing requirements on an annual basis.
- When an agency uses the direct retroreflectivity measurement approach, all signs being measured should be cleaned before retroreflectivity readings are taken to ensure that the full retroreflectivity of the sheeting is measured.
- In general, the age values in the table could assist in guiding agencies in identifying the expected sign life for various sheeting material and sign type combinations. For example, these could be considered in terms of scheduling inspections if retroreflectometer measurements are collected.
- Alternatively, an agency could consult the sign age prediction values in the table to establish a general targeted replacement age. As a sign ages (i.e., approaches 10 years of age), more frequent retroreflectivity measurements or observations/inspections would need to be taken (i.e., yearly) to ensure that premature sign failures are identified.
- Agencies that manage sign retroreflectivity by replacing signs at the end of the manufacturer warranty period could consider a conservative approach of extending that replacement date by approximately five years based on the observations of this work. A parallel approach, such as nighttime inspections, should be done to identify signs that may be deteriorating at a faster rate before the replacement age has been reached.
- Aside from the results and recommendations presented here, agencies must continue to monitor sign condition for failure factors other than retroreflectivity, such as ensuring that signs retain their intended color (i.e., red and not faded pink for a Stop sign), are clean, are not vandalized, etc.



Tom McDonald, Iowa LTAP

Nighttime view of curve warning sign and chevrons



David Veneziano, Iowa LTAP

Vandalized and faded signs

Data Collection and Future Research Recommendations

- When a sign is replaced, particularly when sign retroreflectivity measurement is the management approach being used by an agency, the sheeting material of the sign should be updated in the sign database. In other words, if a Type III sign is installed to replace a Type I sign, the database should be updated accordingly to reflect the current material (while still retaining the historical documentation related to the prior material).
- Future research could investigate modeling approaches that incorporate multiple factors that impact sign retroreflectivity in combination. For example, solar radiation levels, weathering exposure, foliage shading, and other related data could also be collected and incorporated into a more robust modeling approach. The collection of that site-specific data is likely to be time consuming and costly and would require a large-scale, dedicated research project collecting all of the relevant data from start to finish.
- Future research should evaluate larger sample sizes for certain materials and sign types/colors that were underrepresented in this project (green and white guide signs, for example).
- In future research, it would be preferable to track sign retroreflectivity from the installation date through retirement, at least for a sample of signs in the field to track trends for specific signs on a reliable timeline. This recommendation is based on observations made from the sign databases accessed during this research, where it was clear that a sign had been replaced at a given point in time, and yet retroreflectivity readings from before that replacement date were also present in the data set. Ideally, a research effort would start with a sample of new signs and follow the history of each to failure. Such an evaluation would likely last over the course of decades.