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Analysis Of The Road Markings Reflectivity Service Life On Highways To Improve Safety

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Abstract

Road markings can function for two years after installation. The maintenance and replacement program for highway markings aims to meet the established performance standards. Good visibility of the markings will help reduce the chances of traffic accidents. The problems are found in faded road markings along the segment during the service period. The research was conducted to investigate the change in reflectivity over time and to find a pattern of decreasing reflectivity in the service life during the design life. The research was conducted experimentally by making test objects. The reflectivity test at the existing location using a reflectometer is carried out periodically every two months. The results showed a pattern of decreasing the reflectivity of road markings during the 2-month service period by 2%, four months by 3%, six months by 6%, and eight months by 16%, and the pattern of declining marker reflectivity stops between 10 and 12 months. The maximum decrease occurred during the service period of 8 months, 16%. The age of markings on the highway cannot last for a service period of 2 years under actual conditions in the field. At the end of year 1, the average value was 242 mcd/m^2/lux; this value is below the minimum required reflectivity of 250 mcd/m^2/lux.

Keywords: *Thermoplastic Markings, Road Markings, Thermoplastic, Reflective, Degradation*

INTRODUCTION

Road markings can perform during the service life of 2 years. However, during the service period, the markers can experience various damages that affect their lifetime. However, during the service life, the markers can suffer various damages that affect the design life. Damaged road markings can reduce driver visibility and affect traffic operations and the safety level of highway users. Damage to road markings causes disruption of road functions in serving road user traffic. Driving at night requires clear directions to help the driver navigate in low visibility conditions. The reflectivity of road markings is the ability of guide signs to reflect light from the headlights into the driver's eyes. Good visibility of the markings is necessary to support the level of safety because it helps reduce the risk of traffic accidents. In the operational and maintenance management system of toll roads, road markings are part of the safety system that can be improved by regular maintenance according to quality management standards. Unclear road equipment, such as the reflectivity of markings, contributes to accidents at night. The problems are found in faded road markings along the segment during the service period. At the age of 1 year, the average existing reflectivity value is below the minimum reflectivity standard specification of 250 mcd/m^2/lux for the highway at the end of the 1st year (Oktopianto & Hidayat, 2020).

Several studies have been developed, both technical and non-technical, such as public perceptions of the brightness level of road markings. The Minnesota Department of Transportation (MnDOT) conducted a study to establish a reflectivity threshold value for use in a road marking

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management program; as a result of the research project, MnDOT will use 120 mcd/m^2/lx as the threshold between acceptable reflectivity and unacceptable reflectivity at new road marking management programs (Loetterle et al., 2000). Age evaluation studies of road markings with mathematical models include the findings of the MC model where this model connects the reflectivity and age of road markings with traffic conditions (Chimba et al., 2018), the logarithmic relationship between reflectivity and age, linear models based on age and traffic volume (Ozelim & Turochy, 2014) predictive model for marking paint, degradation model to determine remaining life, where model parameters that implement data structures and model predictions to estimate asset condition at any time in the highway system (Sitzabee et al., 2009).

The study was on federal road FT005 in Selangor and involved repainting road markings with thermoplastic road marking material along the identified locations. Data collection was carried out during the day and at night. This study's findings reveal a significant interaction between the type of road marking and the time of observation of the lateral position of the vehicle during the day and night (Aznirahani et al., 2018). Taylor and Francis Group, LLC conducted a similar study to determine the reflectivity performance of road markings. This study examines the effect of reflectivity in the field by simulating rain. During rain, markings covered by water reduce reflectivity and affect the visibility of markings at night (Hadi & Sinha, 2011).

It has been demonstrated that road safety can be improved by increasing the visibility performance of road markings. The evaluation results show that thermoplastic road markings with glass beads outperform other road marking systems tested in reflectivity. The increase in reflectivity substance is considered a beneficial factor in increasing the driver's visibility (Hadi & Sinha, 2011). Another study developed a spatial-temporal database using reflectivity and accident data to measure the relationship between collisions and the reflectivity of road markings. A reflectivity value of 200 mcd/ m^2/lx or less has a significant relationship (Hadi & Sinha, 2011).

A test was conducted to develop a laboratory-based evaluation procedure that can evaluate and study the performance of road markings by imitating different traffic and weather conditions. There was a decrease in physical properties, namely reflectivity, color change, and marker durability. The results illustrate that the performance logarithmically deteriorates under different loadings, except for the resistance of thermoplastic markers (Mohamed et al., 2020). Road markings must be replaced once the reflectivity falls below the specified standard.

From previous studies that measured the level of degradation of marker reflectivity between various materials, it is recommended to investigate the time-based changes in the reflectivity of thermoplastic markers to find a pattern of decreasing marker reflectivity over time (Clarke & Xuedong, 2010). This research was developed based on previous research, which only came to a review of the degradation of various road marking materials. This study will investigate changes in the reflectivity of thermoplastic markings based on age to find a pattern of decreasing reflectivity of markings over time during service life as an evaluation material for the operation and maintenance of road markings for highway operators.

LITERATURE REVIEW

Potential causes of traffic accidents can be caused by a decrease in the physical condition of the road or its accessories, errors in the application of complementary buildings, and a decrease in road environmental conditions. Road markings are essential equipment in supporting driving safety.

Based on the Regulation of the Minister of Transportation of the Republic of Indonesia Number 34 of 2014 concerning Road Marking, a road marking is a sign that is on the road surface or above the road surface, which includes equipment or signs that form longitudinal lines, transverse lines, oblique lines and other symbols that function to directing traffic flow and limiting areas of interest to traffic. The installation of road markings is essential in providing instructions and information to road users. In some cases, markings are used as an additional traffic control tool. As part of the traffic control system, road markings are intended to improve traffic safety, provide instructions and warnings to road users so that traffic operations become safer and smoother.

Toll road maintenance is an effort to part or all road elements to maintain, restore or improve road conditions so that they remain within the limits of the minimum service standards of toll roads. Road markings are safety indicators that must be met. The performance standards that have been set in the Minimum Service Standards (SPM) are the substance of the safety service of road marking indicators that the presence of road markings must be 100%, and the reflectivity of road markings must be >80%, so that to achieve these standards, toll road managers must carry out repairs/repaints for safety. and convenience of toll users. This work aims to carry out periodic maintenance activities by replacing road markings. While the goal is to meet the performance standards that have been set in the SPM. Based on the Regulation of the Minister of Transportation of the Republic of Indonesia Number: PM 26 of 2015, toll road markings must have an average reflectivity level of at least 300 mcd/ m^2/lux at the age of 0-6 months and the end of the 1st year an average reflectivity level of at least 250 mcd/ m^2/lux.

The reference standard for special specifications for thermoplastic road markings refers to the Indonesian National Standard (SNI), Technical Guidelines: SNI 06-4826-1998 Specifications for White Reflective Thermoplastic Paint for Road Markings, SNI 15-4836-1998 Specifications for glass beads for road markings., AASHTO M 249-79(98) Material Thermoplastic, AASHTO M 247-09 Material Glass Beads. The material used in this test is a thermoplastic road marking consisting of light-colored aggregate (filler), pigments, beads, and extenders, which are mixed into the thermoplastic resin. Glass beads are sprinkled (on the drop) or mixed with paint material that is sprayed to make road markings reflectivity or reflect light. The composition of the mixture used is shown in Table 1.

Table 1. Mixture of Thermoplastic Materials

Components	White Color
Binder	18 % Minimum
Glass Beads	30-40%
Titanium Dioxide	10 % Minimum
Calcium Carbonate	42% Minimum
Filler	

Source: Terms of Reference of PT. Citra Marga

RESEARCH METHOD

This research was conducted on the Ir. Wiyoto Wiyono, M.Sc on the Cawang-Tanjung Priok section (North South Link/NSL). The research location is P181 - P182, which was determined based on secondary data and the results of routine inspections by the highway manager of the Planning and Maintenance Division of PT. Citra Marga Nusaphala Persada Tbk. The research was conducted experimentally by making test objects at existing locations.

Testing is carried out periodically every two months, with the first test at the age after application. This approach was carried out to observe the pattern of decreasing the reflectivity value of road markings during the service period until the service life of 1 year. The test of the level of reflectivity of the markers was carried out at night. The reflectivity test of road markings is carried out at the existing location using a reflectometer. The process of making test objects and testing methods at the existing location with the following steps:

a. Inspection at the research site.
b. Determination of test locations based on secondary data and inspection results.
c. Cleaning the location to be marked, at this stage, stripping the old marker using a Torch Gun until it is clean.
d. Making marking patterns according to geometric conditions to determine the limits to be tested.
e. Making test objects in 5 locations, namely at P181-P186
f. The markers that have been installed are left for 5-10 minutes before the first reflectivity test is carried out.
g. Reflectivity test using Easylux Reflectometer
h. Periodic testing every 2 months during service life.
i. The results of reflectivity and pattern of road marking decline with time.

FINDINGS AND DISCUSSION

The test of the reflectivity of the marking was carried out on the test object to observe the difference in the level of reflectivity and behavior of the thermoplastic road marking material with respect to time during its service life. Testing for each location was carried out seven times, located at P181-P186. Making test objects and testing road markings are carried out on module markings which are carried out at night to get more accurate results. The testing approach is carried out periodically every two months to observe the pattern of changes in reflectivity values that occur in the field directly during the service period. The results of the reflectivity test of road markings in the first test after the road markings are applied until the age of 6 months can be seen in Figure 1.

Tests were carried out on test objects located at P181-P186. The first test was carried out after the deployment of the markers was completed. This test was carried out as a benchmark for the basic value to observe the pattern of decreasing reflectivity values in the next test. Figure 2 shows the pattern of decreasing the actual reflectivity value of road markings based on time for six months that occurred in the field. In the first test until the third test at the age of 4 months, the average reflectivity value of the road markings obtained still meets the technical requirements, namely highway markings must have an average reflectivity level of at least 300 mcd/ m^2/lux at the age of 0-6 months. In the 4th test, at six months, there was a decrease in reflectivity values below 300 mcd/ m^2/lux in all test objects.

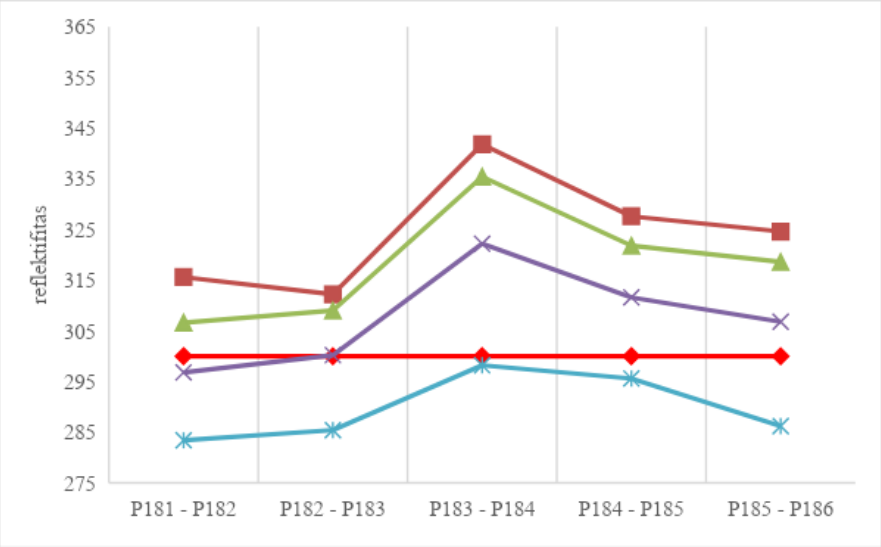

Figure 1. Results of the Reflectivity Test until the Age of 6 Months

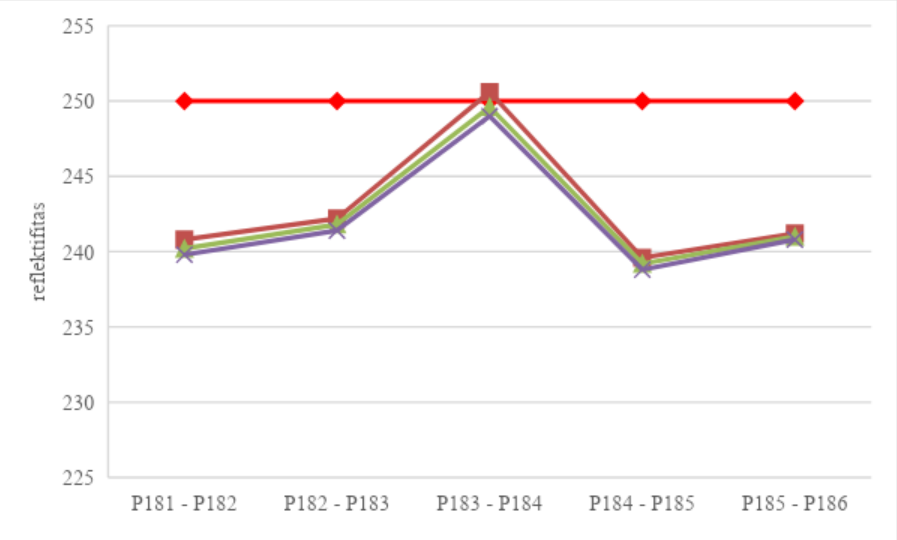

Figure 2. Results of Reflectivity Testing for Ages 8 – 12 Months

Furthermore, the test was carried out at 8 months to 12 months. This observation was carried out to obtain a pattern of decreasing reflectivity of road markings at the end of the 1st year where the technical specifications that must be met at the end of the 1st year average a minimum reflectivity level of 250 mcd/ m^2/lux. Figure 6 shows the results of the pattern of decreasing reflectivity of road markings at the end of the 1st year, with the results that all points on the P181-P186 test objects experienced a significant decrease in the reflectivity value and exceeded the minimum required limit.

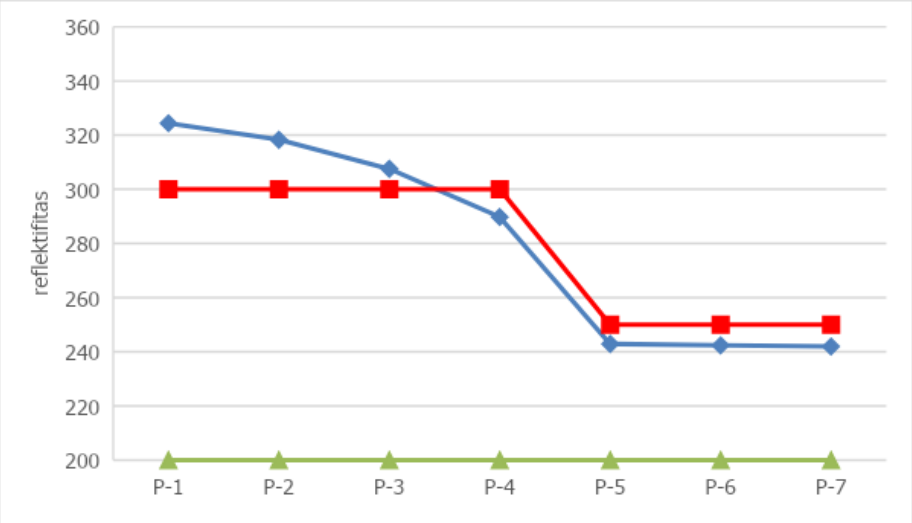

Figure 3. Recapitulation of 1 Year Reflectivity Testing

Figure 3 is a pattern of decreasing the reflectivity value of thermoplastic road markings for one year, which is tested periodically every two months. This testing approach is carried out to obtain a pattern of decline based on time. In the 4th test at the age of 6 months, the average reflectivity value obtained is 290 mcd/ m^2/lux below the specified specifications, namely highway markings must have an average reflectivity level of at least 300 mcd/ m^2/lux at the age of 0- 6 months.

The maximum decrease occurred in the 5th test at the age of 8 months, where there was a decrease in the reflectivity value of 16%. In the next test, there was no further decline after the maximum decrease occurred at 8 months and 1 year. Based on the results of observations in the field, this occurs because the glass beads, which function to increase the visibility of road markings at night or in dark conditions, have mostly eroded. At the end of the first year of testing, the average value was 242 mcd/ m^2/lux; this value is below the minimum required reflectivity of 250 mcd/ m^2/lux. Technically, from the test results, the average reflectivity value obtained at the end of the 1st year is 242 mcd/ m^2/lux. Factors that affect the decrease in reflectivity of markings include the type of road surface, vehicle volume, and road elevation (Debaillon et al., 2008). Previous research has shown that traffic volume affects the service life of road markings (Owusu et al., 2018; Lertworawanich & Karoonsoontawong, 2012).

This research was developed to complement previous research from the prediction model of marker degradation on the remaining service life by (Sitzabee et al., 2009) into field observations to determine the behavior of the actual road marking decline pattern during the service period. The results of this study complement previous studies with the results of the actual reflectivity reduction pattern in the field, a maximum decrease at the age of 8 months with a percentage decrease of 16%. After the maximum decrease, the reflectivity of the road markings stopped and did not decrease again. Observations were continued until the end of year 1 to investigate the actual behavior of road markings during the service period. An investigation of changes in reflectivity over time to thermoplastic markers was carried out to find a pattern of decreasing reflectivity of markers based on time and is a follow-up study of (Clarke & Xuedong, 2010) with the results of a pattern of

decreasing reflectivity at two months of age by 2%, four months by 3%, six months by 6%, eight months by 16% and 10 to 12 months the pattern of decreasing marker reflectivity stopped and did not decrease again.

These results indicate that the road marking age on the highway cannot last for two years under actual conditions in the field. These results answer the problems in the field regarding the number of faded markings found from the results of road maintenance inspections during the design life. This result can also be used as an evaluation material between highway operators and road marking applicators in determining the retention period starting from Provisional Hand Over (PHO) to Final Hand Over (FHO). Furthermore, these results can be used as a reference for planning maintenance of road markings for highway operators.

CONCLUSION AND FURTHER RESEARCH

Thermoplastic markings on the highway cannot last for a 2-year design life under actual conditions in the field. It was found that the pattern of decreasing the reflectivity value of road markings was as follows: during the service period of 2 months, the reflectivity decreased by 2%, 4 months by 3%, 6 months by 6%, 8 months by 16% and 10 to 12 months the pattern of decreasing reflectivity of stop markers. The maximum decrease occurred during the service period of 8 months 16%. At the end of year one, the average value was 242 mcd/ m^2/lux; this value is below the minimum required reflectivity of 250 mcd/ m^2/lux. This research can be further developed to compare the service life performance on yellow road markings.

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