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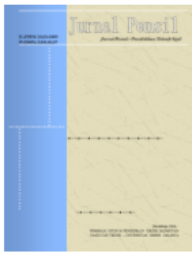

GLOW IN THE DARK MEDIAN FRONTAGE AND PEDESTRIAN AS A GUIDE FOR DRIVERS AT NIGHT

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Abstract

The condition of the road plays a significant role in the driving experience and traffic safety. This research utilizes a Pre-Experimental Design approach to develop phosphorescent paint technology for sidewalks. The main goal of this research is to create a solution that aids the visualization of drivers and pedestrians in dark road conditions. Additionally, the research aims to reduce excessive electricity consumption, which is a crucial step in supporting efforts to mitigate global climate change. The research results show that the application of phosphorescent paint on sidewalks can enhance visibility at night and provide clear visual guidance for road users. This technology also successfully reduces reliance on external street lighting, resulting in significant electricity savings. Thus, this research makes a positive contribution to improving traffic safety and supporting energy conservation efforts to protect the environment.

Keywords: Glow in the Dark, Pedestrian, Median Frontage

Introduction

Research Background

Adequate road conditions and effective lighting are two key factors in road user safety and comfort (Khoirunnisa et al., 2022). When it comes to highways, it's not just about smooth asphalt surfaces or clear road signs, but also about how well the road allows drivers to see clearly and feel safe while driving. This is especially crucial during nighttime or in adverse weather conditions (Oktegianda et al., 2019). Every road segment requires different road equipment, including traffic signs that provide directional guidance, road markings that define boundaries, signal devices that regulate traffic. One of the most critical aspects of this road equipment is street lighting (Pane et al., 2021).

In Indonesia, public street lighting, represented by Street Lighting (LPJU), remains a concern that needs attention (Arirohman et al., 2021). Many road segments still lack adequate illumination, and in some locations, the light intensity produced by LPJU does not meet the established standards. Another common issue is uneven light distribution, causing some areas to be very dark while others may be overly bright (Shamin & Demak, 2018). The lack of street lighting not only affects nighttime driving comfort but also increases the risk of traffic accidents. In dark road conditions, road signs, road markings, and other road users are difficult to see, which can lead to accidents (Sari & Yudhistira, 2021).

Furthermore, dark road conditions also increase the risk of criminal activities because wrongdoers find it easier to conceal themselves in the darkness (Azarine & Satiawan, 2019). According to SNI-04-6262-2000, PJU (Public Street Lighting) is a type of lighting that illuminates roads at night for pedestrians, cyclists, and all road users to enhance road safety. Inadequate public lighting conditions continue to be a common issue in various regions, particularly in the city of Bandung. Some news reports have revealed that some residents of Bandung have complained about the darkness of certain road segments in the city due to damaged streetlights (Khayam et al., 2023). Like the accident cases that occurred in Cibiru sub-district, Bandung city, most of them were triggered by various factors such as the lack of lighting, lack of traffic signs, and the low level of legal awareness among drivers (Yuianti & Putri, 2023). Based on information from the Head of Infrastructure Division of the Bandung Transportation Department, the city needs approximately 19,422 street lighting points (Wicaksono et al., 2019).

Based on the existing issues, intend to create an innovative work to support improved lighting on road sections, namely the "Glow in The Dark Median Frontage and Pedestrian" as a guide for drivers at night (Hargianti et al., 2023). Designed the production of sidewalks.

Coated with a mixture containing strontium aluminate phosphors that can store solar energy and emit it in the dark, with the hope that it can be used as an alternative to electricity. This innovation aims to assist drivers in feeling safe and comfortable while driving at night (Hargianti, 2021).

Research Problems

The formulation of the problem in this research are (1) How is the resulting composition so that it can be used for sidewalks? and (2) What are the advantages of using phosphors paint on sidewalks?

Research Purposes

Based on the formulation of the research problem, the purposes of this research are to obtain the optimum composition with the ideal content of strontium aluminate phosphors in the sidewalks paint mixture for finishing, and also to produce a ready-to-apply sidewalks paint mixture with strontium aluminate phosphors.

Road Stripe Paint Definition

According to the Minister of Transportation Regulation (Peraturan Menteri Perhubungan) No. 34 of 2014, "marka jalan" is defined as road markings or road stripes, which are signs located on or above the road surface, including devices or signs that form vertical, horizontal, or diagonal lines, as well as symbols used to guide traffic and depict areas of traffic interest. According to SNI 06-4825-1998, "cat marka jalan" is defined as a type of liquid or solid paint applied to the road surface as road markings (Balitbang, 1998). It can be concluded that road markings are a crucial component of the traffic system, which includes signs, vertical lines, horizontal lines, diagonal lines, and symbols placed on or above the road surface (Efendi, Agung and Andriawan, 2023)is. Meanwhile, road marking paint is a liquid or solid paint applied to the road surface as road markings (Nurdin et al., 2022).

Function of Road Markings

Road markings are not merely decorative elements; they also serve as crucial guidance tools for traffic users (Mardiana, 2020). Road markings provide clear visual guidance through vertical, horizontal, and diagonal lines and symbols to direct traffic, warn drivers of hazards, and guide them in using the road. Therefore, road markings assist in creating traffic order, reducing the risk of accidents, and enhancing safety for road users (Handayani et al., 2019).

Road Marking Paint Type

There are common types of road marking paints that are often used, such as (1) Water-Based Paint that uses water as a solvent and is environmentally friendly (Paiano et al., 2021); (2) Thermoplastic Paint that made from a mixture of thermoplastic, pigments, and fillers (Oktopianto & Rukman, 2021); (3) Solvent-Based Paint that contains organic solvents in its composition (Huang et al., 2024); and (4) Luminescent Paint that highly effective at night and in low-light conditions. Luminescent paint is often used in accident-prone areas or for specific guidance at night (Al-Qahtani et al., 2022).

Colors and Symbols in Road Marking Paint

According to the Regulation of the Minister of Transportation of the Republic of Indonesia Number PM 67 of 2018 regarding Amendments to the Regulation of the Minister of Transportation Number PM 34 of 2014 concerning Road Markings, it considers that road markings have regulated the use of white for vertical lines. Vertical lines are white for national highways and white for non-national roads, with yellow vertical lines being solid and/or dashed lines used to separate and divide lanes, as well as solid lines used as warning signs on the right edge of the road or traffic lanes (Sirait et al., 2018).

Nighttime Illumination

Artificial lighting is lighting that uses artificial light sources, especially lamps. Artificial lighting is required during the evening, nighttime, or in dark conditions (Az-Zaky et al., 2023). The advancement of technology in artificial light sources has brought high-quality artificial lighting to fulfill human needs. The availability of lighting as a supporting function for the continuity of road activities at night is crucial (Rudini et al., 2021).

Street Lighting (Lampu Penerangan Jalan Umum - LPJU) is public lighting at night for pedestrians, cyclists, and other road users to be clearly visible to drivers in dark conditions (Direktorat Jenderal Energi Baru Terbarukan dan Konservasi Energi & Mineral, 2014). main purpose of LPJU is to enable safe travel for users of cars, motorcycles, bicycles, and animal-drawn vehicles, to provide well-lit positions for pedestrians and increase safety awareness, and to illuminate the surroundings during nighttime (Sukma et al., 2021).

Phosphor Powder Definition

Glow in the dark phosphor is a type of phosphor that can absorb light and then re-emit it as light after the original light source is removed (Suprianingsih, 2019). This property is often referred to as phosphorescence. This understanding is based on the fundamental properties of phosphorescence. Phosphor glows in the dark and, when exposed to a light source, it absorbs light energy and stores it as electronic energy (Hai et al., 2021). When the light source is removed, the stored energy is released as light, creating a glow-in-the-dark effect. Phosphors that glow in the dark are typically used in applications that require visual guidance at night, such as road markings, evacuation signs, and consumer products like toys or children's stickers (Zhao et al., 2021).

Use of Phosphorence in Road Marking Paint

In Indonesia, there is currently no implementation of phosphorescence in road marking paint (Nance & Sparks, 2020). However, phosphorescence has benefits and roles in traffic, especially at night, including:

1. Improved Nighttime Visibility. The use of luminescent road marking paint ensures that road markings remain visible even with minimal lighting at night, providing clear visual guidance for drivers (Sharma & Tan, 2021).
2. Clear Guidance Glow in the dark road markings help drivers stay on the correct path, identify road boundaries, and avoid hazardous crossings (Saleem & Hosoda, 2021).
3. Benefits for Pedestrians. Phosphorescent road paint also contributes to pedestrian safety. Bright road markings help pedestrians cross the road more safely (Ismail & Nazri, 2019).

Improved Nighttime Visibility

The use of luminescent road marking paint ensures that road markings remain visible even with minimal lighting at night. This provides clear visual guidance for drivers. Road markings with good reflective properties can enhance driver visibility and reduce the risk of traffic accidents at night (Fiolić et al., 2023). Road markings with good reflective properties can also assist drivers in estimating the distance and speed of vehicles in front of them, reducing the risk of rear-end collisions. Road markings with good reflective properties can also assist drivers in estimating the distance and speed of vehicles in front of them, reducing the risk of rear-end collisions (Fiolić et al., 2023).

In low-light conditions or at night, driver visibility becomes crucial to avoid accidents. Clear visual guidance such as traffic signs, road markings, and directional indicators are very helpful for road users to navigate safely. Road markings with good reflective properties provide effective guidance, especially at night (Darko Babi et al., 2020). Furthermore, road markings assist drivers in distinguishing between the correct and incorrect lanes and help them avoid obstacles or hazards on the road. Road markings with good reflective properties also aid drivers in estimating the distance and speed of vehicles in front, thereby reducing the risk of rear-end collisions. The use of road markings with good reflective properties also helps drivers anticipate the distance and speed of oncoming vehicles, reducing the risk of head-on collisions (Garach et al., 2022).

Accident-Prone Area

Accident-prone areas, where the use of road marking paint is crucial, can include area such as (1) urban areas with high traffic volumes; (2) rural areas with winding roads and steep slopes; (3) areas frequently used by pedestrians; (4) flood-prone areas and extreme weather conditions; and (5) areas with sharp turns or narrow-roads. Glow-in-the-dark road markings are often used in accident-prone areas, such as crosswalks near schools or pedestrian zones. This helps reduce the risk of traffic accidents in these locations. Additionally, glowing road markings also enhance the

safety of pedestrians when crossing the road (Darko Babi et al., 2020). Glow-in-the-dark road markings typically have a long lifespan and can maintain their ability to glow in the dark for a significant duration. The durability of glow-in-the-dark road marking paint is crucial for ensuring effective guidance and long-lasting performance (Lin et al., 2023). Therefore, the use of glow-in-the-dark road markings in accident-prone areas can contribute to improving road user safety and reducing the risk of traffic accidents at night.

Research Methodology

Study that seeks to determine, under controlled circumstances, how the independent variable affects the dependent variable (Mulyani, 2021). Pre-experiment-post-experiment study involves doing two examinations of a single subject: one prior to intervention or action being performed, and one subsequent to it. Even in situations when a continuous control group is unavailable for comparison, this approach can show changes in comparable groups both before and after interventions (Hastjarjo, 2019).

Figure 1. Research Procedure

Based on the methodology flowchart that has been designed, below is an explanation of each process according to the methodology that has been made.

1. Researchers started research activities by identifying dark road problems in the Bandung City area.
2. Researchers begin to examine the problem with relevant literature studies.
3. Literature study, namely reviewing various journals, theses, bibliographies, and specification regulations regarding Accessibility Needs at the research location. To find out research that has been done in the past related to the variables and factors studied, the methods used, and the results and obstacles found in the research.
4. Data collection, in this study consists of two types of data, namely data from paint testing results using phosphor and not using phosphor.
5. Field observations were conducted to find out how dark the highway was at its actual location.
6. Paint testing is carried out to determine the appropriate composition so that the phosphor can glow maximally.
7. After successful testing, CAT was implemented to locations in need, in this study the location was Jl. Setiabudhi, Bandung.
8. Researchers provide conclusions regarding the prioritization of handling, as well as the determination of accessibility values that can be used as consideration for making policies.

9. Research completed.

Research Results and Discussion

Pre-Test

At the pretest phase, visual inspection is conducted in the morning to determine the initial condition before removing the cat's feces. The purpose of this research is to understand some of the local lighting before intervention.

Interventions

a. **Setting Up the Site**. Clear the kanstin of any debris or dust that can prevent paint from adhering to it in order to prepare the area for applying phosphor paint. Priming or cleaning the kanstin surface can also be done if needed.
b. **Paint Mixtures**. Phosphorus paint needs to be well swirled in order to achieve the best possible results, since this will guarantee that the phosphorus is dispersed uniformly.
c. **Paint Application**. The kanstin is painted with phosphor paint using the proper methods or equipment. Depending on the project's size and requirements, this could use rollers, brushes, or spray equipment.
d. **Drying Time**. The paint is allowed to dry for the amount of time specified by the manufacturer after usage. Additional lighting may be needed for phosphor paint to activate its phosphorescence capabilities before it dries.
e. **Quality Check**. A quality check is done once the paint has dried to make sure the phosphor paint was applied correctly and produced the appropriate amount of phosphorescence.

Implementation

The implementation process of the "phosphorescent paint for sidewalks" product begins with a crucial step in ensuring an adequate supply of phosphorescent paint. This involves mass production of phosphorescent paint according to the previously tested and approved composition. There are three ratios of varnish and strontium aluminate phosphorus paint mixtures; The composition of the first varnish paint is 1:1, the second composition is 1:2, and the third composition is 1:3. For example, a 1:2 composition represents 200 grams of varnish paint compared to 400 grams of strontium aluminate phosphorus. The composition with the maximum light emission is the third composition with a ratio of 1:3. The composition with the highest light emission, with a ratio of 1:3, is the third composition. Mass production is necessary to ensure that there is a sufficient stock of phosphorescent paint to meet the application requirements at various designated road or sidewalks locations.

Next, the next step is site preparation. This is a critical field preparation stage, where the locations to be painted with phosphorescent paint must be carefully prepared. This preparation includes several aspects, including:

1. Site Cleaning: The area to be painted with phosphorescent paint must be thoroughly cleaned. Dust, dirt, and other particles should be removed to ensure the paint adheres well to the sidewalks surface.
2. Evaluation of sidewalks Condition: The physical condition of the sidewalks must be evaluated. This includes checking the surface's evenness, identifying any damage, or cracks that need repair before paint application.
3. Primer Coating: In some cases, a primer coating or initial layer application may be required before applying phosphorescent paint. This is done to ensure that the phosphorescent paint adheres well and emits optimal light.

Therefore, site preparation is a crucial step to ensure that phosphorescent paint is applied effectively and can provide adequate visual guidance to road users. Here is the documentation of the product implementation that has been carried out.

Figure 2. Comparison of Paint Compositions

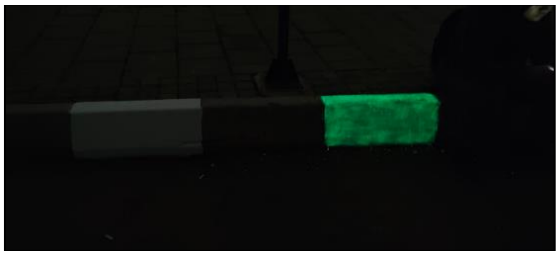

Figure 3. Comparison of Phosphorescent Paint and Regular Paint at Night

Maintenance

Maintenance of phosphorescent paint is a series of periodic actions to ensure that the phosphorescent paint continues to function properly and emit light with adequate intensity. This maintenance is a proactive step to preserve the quality and effectiveness of the phosphorescent paint over time. The maintenance process involves several steps, such as regular inspection, cleaning, repainting, and reapplication. These maintenance steps ensure that the phosphorescent paint continues to provide effective visual guidance for road users and remains a valuable tool in enhancing traffic safety.

Conclusion

The conclusion from the development and implementation of phosphorescent paint on sidewalks is that this innovation has significant potential in enhancing road user safety and comfort, especially during nighttime or low light conditions. Several key points can be summarized:

1. Ideal composition ratio is 1 varnish : 3 phosphor. In this ratio, phosphorescent paint may emit brighter light, but consideration should be given to avoid excessive brightness that could potentially disrupt road users. Because there is more phosphorous mixed in than varnish paint, the paint can absorb and shine more optimally, which results in a brighter light in this ratio.
2. The benefits of applying phosphorescent paint on sidewalks have been clearly demonstrated in improving traffic safety and providing effective visual guidance for road users, particularly during nighttime or low-light conditions. Additionally, this innovation also has a positive impact on saving electricity, reducing reliance on external street lighting, and potentially creating economic opportunities. With proper maintenance and appropriate composition, phosphorescent paint on sidewalks has significant potential to support urban mobility's comfort and safety while reducing environmental impact.

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